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VOLUME XII, PART VI

(December 1942)

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ORIGINAL ARTICLES

HE NATURE AND EXTENT OF DAMAGE CAUSED BY *BEMISIA GOSSYPIPERDA* M. AND L., THE WHITE-FLY OF COTTON IN THE PUNJAB

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(With Plate XXXI and two text-figures)

INTRODUCTORY

THE economic importance of some of the species of Aleurodidae has now been definitely recognized and a number of them are known as serious pests flower plants, fruit trees and cultivated crops. In India some of the white-s which are responsible for causing considerable economic loss to growers, *Dialeurodes citri* and *Dialeurodes elongata* on citrus ; *Aleurolobus baro-isis* on sugarcane ; *Aleyrodes ricini* on castor and *Bemisia gossypiperda* cotton. The damage by the white-flies in the respective cases is quite ilar, since unlike most other sucking insects the mechanical injury is not preciable and yet the after-effects of the attack are very serious.

So far, no precise information, however, is available with respect to the l nature of injury caused to the infested plants. According to Berger 10] and Morril and Back [1911], Aleurodidae have never been accused of ing the plant tissues. This is evident even in the case of the citrus plants ich are slow growing and where the white-fly infestation is carried r from year to year on the leaves of the same plant. Notwithstanding heavy infestation in certain cases, the leaves attain almost normal and shape but the fruit, on the other hand, is comparatively less developed l considerably reduced in number.

As a pest in greenhouses, Lloyd [1922] regarded the white-flies as res-nsible for lowering fruit formation as well as for desapping the vitality of leaves and some times causing them to drop. This contention has re-ved support from Hasement and Jones [1934], but the exact condition and of the plants when the leaves were shed have not been described.

Virus diseases of a number of field crops have been associated with the te-flies. Golding [1930], Kirkpatrick [1930-31] and Massey and Andrews 32] hold white-flies responsible for leaf crinkle of cotton in the Sudan

Hopkins [1932] and Mossop [1932] regard a species of Aleurodidae as a ca of the leaf-curl disease in tobacco at Rhodesia. Mathur [1933] regar *gossypiperda* as a vector of leaf-curl in zinnia at Dehra Dun, while Pruth Samuel [1937 ; 1939] consider the same species responsible for the transmi of leaf-curl virus in tobacco at Pusa (north Bihar).

As a pest of cotton, it has been discussed previously by Husain [and Husain and Trehan [1933] that the white-fly is not capable of prod any structural malformation of foliage or any other part of the plant. any rate, it is quite obvious that thousands of white-fly nymphs which generally present on an infested plant, must deprive the host of its nou ment by constantly sucking the vital juices. Besides, these nymphs se copious quantities of honey-dew which falls on the leaves below and pro a suitable medium for the growth of a black mould. Thus the int metabolic activities of the plant are also disturbed due to interference its photosynthesis.

In the absence of any visible structural injury to the plant, even in of severe infestation, and under the conditions stated above, it was consid necessary to investigate in what manner these insects damage their and bring about the resultant effects. Since it is universally recogn that fruiting in cotton plants is affected considerably by the relative turbance in the products which are manufactured in the foliage, it was gestive that the nature of injury might be determined by investigating rôle of this pest in affecting the production of certain plant constitu Moreover, the extent of damage as a result of the white-fly attack required estimation.

Attempts have, therefore, been made to investigate the following asp of the problem :

1. Injury caused to foliage or entire plant
2. The effect of attack on the total dry-weight of the parts of a p produced above soil
3. The effect and after-effects of attack on :
   (*i*) Growth of plant
   (*ii*) Flower and boll formation
   (*iii*) Lint and seed development

The present investigations were carried out at Lyallpur from 1931 to under a scheme financed by the Indian Central Cotton Committee, Bom The generosity of the Committee is gratefully acknowledged.

The statistical analysis of the data was carried out by Mr Dwarka N Nanda, Statistical Assistant, Cotton Research Laboratory, Lyallpur. help is gratefully acknowledged.

Technique

All the experiments during these investigations were carried out in wire-gauze cages. Healthy seeds from a single plant were sown in bl under exactly similar cultural treatments. The plants were enclosed in c soon after the first irrigation and ultimately each cage had four to ten pl for general observations. Dry-weight experiments were performed relatively bigger cages and, therefore, sowing was done inside them. E

had about 55 plants but those under observation varied in number in rent years.

In some of these cages the plants were kept almost free from white-fly ck, in others a moderate attack approximately of the same intensity as d in nature every year was maintained, while in still others a very severe station was kept at different periods of growth of the plants.

To produce infestation in the cages, large number of adult white-flies introduced and allowed to multiply. To free the plants from infest-n, however, removal of adults and spraying with rosin compound was rted to.

Present observations

njury caused to foliage or entire plant

The most obvious results of white-fly attack, as already stated, are iesapping of plants and (2) dropping of honey-dew on the leaves on which k mould develops which consequently interferes with their photosynthetic ities.

It, therefore, seemed possible that some injury in the form of internal iological disturbance may be responsible for the low yield of the infested ts. Nitrogen-carbohydrate relationship may be an index of such dis-ance. This was, therefore, studied.

Nitrogen was estimated by Kjeldahl's method and carbohydrates by 'difference method' after estimating ash, fat and crude fibre. The carbo-ate estimation by the 'difference method' is not considered accurate for letermination of the rôle of various sugars or of starch in boll formation. ever, it was considered that comparative values of the total carbo-ates under almost identical conditions, other than the white-fly attack, be of some interest. Fat was estimated by petrol extract in the Soxhlet ratus and the crude fibre from the fat-free samples.

Prior to each observation, the leaves of the healthy and infested plants ted for analysis, were carefully washed with a moist pad of cloth with w to remove, as far as possible, the black mould and the immature s of white-flies, if present. About 24 hours after this treatment, the s and other parts of the respective plants were removed separately, hed, dried and powdered. The representative samples from individual were then taken for analysis.

During 1931, these observations were limited to the selected samples of s from infested and uninfested plants. During 1932, however, such rvations were made after removing the entire leaves from such plants. ng 1933 and again in 1935, these comparative observations were further ided to stems, flowers and bolls as well.

The data recorded in Tables I and III indicate that, as was to be cted, the percentage of moisture was relatively higher in the leaves of least-infested plants than in those of the heavily infested ones. Dry er, on the other hand, was relatively greater in the infested than in un-ted plants. These results are in perfect agreement with those of Johnson 4] who found similar condition in the case of potato plants attacked by eaf-hopper, *Empoasca fabae*,

TABLE I

Results of analysis of leaves of healthy and infested cotton plants, 1931

Date	Nature of infestation	Percentage of moisture	Percentage of dry matter	Weight in 100 gm. of fresh material						C/N	Remarks
				Nitrogen	Protein	Ash	Fibre	Fat	Carbohydrates		
27 July 1931 . .	Low	79·2	20·8	0·68	4·2	2·9	1·4	1·2	11·1	16·3	*Low infestation* Practically free from attack with about 0·19 immature stages per sq. in. of leaf area
	High	77·4	22·6	0·56	3·5	3·4	1·6	1·4	12·7	22·7	
3 August 1931 .	Low	80·5	19·5	0·49	3·1	4·5	1·2	1·2	9·5	19·4	
	High	74·5	25·5	0·48	3·0	6·1	2·0	1·5	12·9	26·8	
11 August 1931 .	Low	80·0	20·0	0·52	3·3	4·9	1·8	0·9	9·1	17·5	*High infestation* Severe attack with 68·0 immature stages per sq. in. of leaf area
	High	76·0	24·0	0·50	3·1	5·6	2·3	1·2	11·8	23·6	
26 August 1931 .	Low	82·5	17·5	0·64	4·0	3·1	1·9	1·0	7·5	11·7	
	High	74·5	25·5	0·38	2·4	7·8	2·7	1·2	11·4	30·0	
28 September 1931 .	Low	77·6	22·4	0·72	4·5	4·8	1·5	1·4	10·2	14·1	
	High	76·6	23·4	0·37	2·3	3·3	1·4	2·1	14·3	38·6	
(1) Mean value of low infestation		79·96	...	0·61	...	4·04	...	1·140	9·48	15·80	
(2) Mean value of high infestation		75·80	...	0·46	...	5·24	...	1·480	12·62	28·34	
(3) Standard error of the difference		1·298	...	0·067	...	1·011	...	0·0927	0·454	3·754	
(4) Mean value of '*t*'		3·205*	...	2·268	...	1·188	...	3·656*	6·916†	3·340*	

* Significant at 5 per cent level
† Significant at 1 per cent level

Further examination of the data collected during 1931 gave the following s :

The average amount of nitrogen in 100 gm. of fresh leaves of the un-ed and infested plants was 0·61 gm. and 0·46 gm. respectively. Thus, gen was relatively higher in the uninfested plants by about 33 per cent. The amount of mineral ash was about 30 per cent higher in the leaves of nfested plants. Similarly the amount of fat and carbohydrates was higher e infested leaves. The C/N ratio, therefore, was lower in the uninfested s, the differences being statistically significant.

Statistical analysis of the data in 1931 showed significant differences in ercentage of moisture, fat, carbohydrates and the C/N ratio in the leaves e uninfested and infested plants.

During 1933 more elaborate observations were made and were con-d till late in the season. Total production of various constituents was lated on the basis of the entire fresh weight of the plants and the relative port from the vegetative to reproductive organs determined (Table II). xamination of the entire data (Table III) it was confirmed that nitrogen elatively higher by 11·7 per cent in the foliage of the uninfested plants e end of August. From September onward, the order gradually reversed e foliage indicating highly significant differences but resulted, on the hand, in the relative increase of nitrogen in the bolls of the uninfested s. Thus a maximum increase of 58·3 per cent of nitrogen over the bolls e infested plants was noticed in the month of November. Moreover, otal nitrogen produced per plant, on an average, was 2·80 gm. in the ested plants against 2·07 gm. in the infested ones. This showed an ase of 35·2 per cent in favour of the uninfested plants. Moreover, of otal nitrogen produced during the flowering and fruiting period, about r cent was estimated to have been transported from the vegetative to eproductive organs in the healthy plants against 4·6 per cent only in nfested plants (Table II). This is an important fact and probably such bolic activities in the plant tissue result in producing fewer flowers and on the infested plants.

Mineral ash. Till the end of September the ash constituents were re-ly higher in the foliage of the infested plants and the differences were tically significant. From October, however, the case was reversed but November, the amount of ash increased considerably in the bolls of the ested plants and went to a maximum increase of 146 per cent over in the bolls of the infested plants. Total mineral ash produced per , on an average, was 17·99 gm. in the uninfested and 13·17 gm. in the ed plants. Thus, about 36 per cent more ash was produced by the ny plants. Moreover, from the middle of October to December, 11·3 ent of the ash was transported to the bolls in the healthy plants against 2·4 per cent in the infested ones (Table II).

Fat. The percentage of fat was comparatively higher in the foliage of ny plants (practically free from white-fly attack) throughout the season when compared to the severely infested ones, the differences were highly icant. During November and December, however, the fat increased derably in the bolls of the uninfested plants reaching to a maximum of

TABLE II

Total nitrogen, ash and fat produced by infested and uninfested plants, 1933

Date	Infested					Uninfested					Remarks
	Plant region	Weight (fresh) (gm.)	Total nitrogen (gm.)	Total ash (gm.)	Total fat (gm.)	Plant region	Weight (fresh) (gm.)	Total nitrogen (gm.)	Total ash (gm.)	Total fat (gm.)	
5 August 1933	Leaves	105·2	0·571	3·956	1·157	Leaves	159·8	1·012	5·705	2·061	I. *Total Nitrogen produced*—
	Stem	94·3	0·243	2·367	0·236	Stem	153·6	0·361	3·149	0·246	(*a*) Infested plants 18·640
											(*b*) Uninfested plants 25·229
18 August 1933	Leaves	206·4	1·106	8·442	1·961	Leaves	249·8	1·429	8·868	2·673	*Nitrogen per plant*—
	Stem	168·7	0·307	2·800	...	Stem	250·2	0·458	4·103	0·425	(*a*) Infested 2·07 gm.
											(*b*) Uninfested 2·80 ,,
2 September 1933	Leaves	280·0	1·772	10·640	3·024	Leaves	359·4	2·005	11·645	3·953	Nitrogen transported to reproductive organs from September onward (Items dated 2 September 1933 and 4 October 1933 deleted because buds not examined)—
	Stem	258·0	0·428	4·051	0·413	Stem	456·2	0·584	5·794	0·639	
20 September 1933	Leaves	206·9	1·223	7·366	2·441	Leaves	305·3	1·578	9·159	3·572	(*a*) Infested—total nitrogen produced 11·640 gm.
	Stem	198·0	0·465	3·366	0·634	Stem	298·0	0·536	4·083	0·715	Nitrogen in buds 0·532 ,,
	Buds *	1·4	0·009	...	...	Buds	10·8	0·063	...	...	Transported 4·6 per cent
4 October 1933	Leaves	319·0	1·844	10·080	3·286	Leaves	370·8	2·084	13·163	4·338	(*b*) Uninfested—total nitrogen 16·377 gm.
	Stem	345·7	0·729	5·739	0·761	Stem	417·0	0·897	6·880	1·126	Nitrogen in buds 3·722 ,,
											Transported 22·7 per cent
23 October 1933	Leaves	403·8	2·463	16·152	4·482	Leaves	406·7	2·229	19·481	5·287	II. *Total ash*—
	Stem	428·6	0·956	...	0·771	Stem	387·3	0·844	...	0·968	(*a*) Infested 118·557 gm.
	Buds	12·3	0·059	0·164	...	Buds	307·4	1·082	2·870	1·260	per plant 13·173 ,,
6 November 1933	Leaves	164·2	0·943	5·233	1·691	Leaves	351·1	1·840	14·785	4·529	(*b*) Uninfested 161·918 ,,
	Stem	148·7	0·355	2·321	0·312	Stem	304·5	0·694	4·872	0·731	per plant 17·99 ,,
	Buds	41·0	0·154	0·419	0·168	Buds	157·8	0·628	1·837	1·136	Transported to buds from 23 October 1933 onward—
											(*a*) Infested 2·4 per cent
29 November 1933	Leaves	340·8	2·072	14·893	2·590	Leaves	393·0	2·012	16·703	3·144	(*b*) Uninfested 11·3 ,,
	Stem	381·0	0·831	7·582	0·610	Stem	476·7	0·925	7·007	0·763	III. *Total fat*—
	Buds	84·5	0·274	0·828	0·287	Buds	270·2	1·386	3·891	5·616	(*a*) Infested 27·26 gm.
											per plant 3·03 ,,
12 December 1933	Leaves	217·9	1·273	8·412	2·004	Leaves	265·2	1·273	10·449	2·864	(*b*) Uninfested 49·00 ,,
	Stem	266·0	0·527	3·884	0·372	Stem	395·5	0·744	6·051	0·595	Per plant 5·44 ,,
	Buds	9·6	0·036	0·062	0·059	Buds	98·3	0·563	1·523	2·360	Transported to buds during November and December—
											Infested 6·4 per

l per cent over that in the bolls of the infested plants. Total amount of t produced per plant, during the season, varied from 5·44 gm. in the un-fested plants to 3·03 gm. in the infested ones. The corresponding transport fat from the vegetative to reproductive organs, during November and cember, was 41·4 per cent and 6·4 per cent respectively (Table II).

Crude fibre. Average amount of fibre produced in 100 gm. of fresh ves of both the uninfested and infested plants was almost equal during e season. During November, however, it increased considerably in the lls of the uninfested plants with a maximum of 292·7 per cent higher than at in the bolls of the infested plants.

Carbohydrates. The percentage of carbohydrates was higher in the liage of the infested plants than in the uninfested ones throughout the ason and the differences were highly significant. On the other hand, the rbohydrates increased considerably in the bolls of the uninfested plants d the difference reached to a maximum of 452·8 per cent during December able III). It is probable that more of non-metabolic carbohydrates are oduced in the infested plants and, therefore, are kept stocked in the foliage d do not migrate to the bolls. On the contrary, it is likely that more of etabolic carbohydrates and relatively less of non-metabolic carbohydrates e produced in the uninfested plants. Thus they are capable of taking part the formation of bolls when migration takes place from the leaves.

Statistical analysis of the data is presented in Table IV, which shows at the differences in the percentage of moisture, fat and carbohydrates in e leaves were highly significant. Nitrogen and ash, however, showed teresting results since the differences in nitrogen in the foliage were signi-ant from September onward and those of ash only up to the end of Septem-r. On the other hand, the data of the entire season compared collectively d not show significant differences. This is quite obvious from the trend the figures in Table III, because in both the cases the migration of the nstituents changes the balance in the foliage.

Similar experiments as above were also started in 1935, but the plants der cages were severely damaged by a violent dust and hail storm. Conse-ently the white-fly infestation as well as the plants under observation did t progress well.

Total nitrogen produced per plant, during the season, was 1·20 gm. in e uninfested plants and 0·95 gm. in the infested ones. At the same time, e percentage of nitrogen transported from the vegetative to reproductive gans was about 20 per cent and 12 per cent respectively.

It is quite evident from the above observations that the most serious fect of a heavy white-fly infestation is the reduction in the amount of total trogen in a plant and consequently its low transport to the reproductive gans. This poverty in proteins is presumably brought about by these cking insects.

Discussion. According to Kraus and Kraybill [1918] plants well supplied th nitrogen and low in carbohydrates are generally highly vegetative. On e contrary, low nitrogen with relatively high carbohydrates, which means a gher C/N ratio, reduces the vegetative growth without a corresponding

TABLE III

Details of analysis of the entire, uninfested and infested plants, 1933

Date of sample	Relative infestation of the plant region	Percentage of moisture	Percentage of dry matter	Percentages from samples as such of					
				Nitrogen	Proteins	Ash	Fibre	Fat	Carbohydrates
5 August	Uninfested leaves	81·2	18·8	0·633	3·956	3·57	1·82	1·29	8·16
	Infested leaves	80·9	19·1	0·543	3·393	3·76	1·77	1·10	9·08
	Uninfested stem	83·7	16·3	0·235	1·468	2·05	7·45	0·16	5·17
	Infested stem	78·3	21·7	0·247	1·543	2·51	9·49	0·25	7·91
18 August	Uninfested leaves	81·5	18·5	0·572	3·575	3·55	2·02	1·07	8·38
	Infested leaves	79·7	20·3	0·536	3·350	4·09	2·11	0·95	9·80
	Uninfested stem	83·9	16·1	0·183	1·143	1·64	7·52	0·17	5·63
	Infested stem	82·9	17·1	0·182	1·137	1·66	8·18	...	...
2 September	Uninfested leaves	81·8	18·2	0·517	3·231	3·00	1·97	1·17	8·83
	Infested leaves	79·1	20·9	0·591	3·693	3·56	2·14	1·18	10·33
	Uninfested stem	80·2	19·8	0·180	1·136	1·37	9·55	0·24	7·51
	Infested stem	76·5	23·5	0·235	1·468	1·70	11·50	0·32	8·51
	Uninfested flower buds, etc.	80·6	19·4	0·596	3·725	...	...	...	...
	Infested flower buds, etc.	81·5	18·5	0·673	4·206	...	...	...	...
20 September	Uninfested leaves	81·4	18·6	0·558	3·487	3·24	2·12	1·10	8·65
	Infested leaves	78·9	21·1	0·633	3·956	3·80	2·58	1·08	9·68
	Uninfested stem	86·3	13·7	0·128	0·800	1·27	6·49	0·14	5·00
	Infested stem	83·5	16·5	0·166	1·037	1·57	8·03	0·16	5·70
4 October	Uninfested leaves	80·9	19·1	0·562	3·512	3·55	2·25	1·17	8·62
	Infested leaves	79·8	20·2	0·578	3·612	3·16	2·46	1·03	9·94
	Uninfested stem	76·1	23·9	0·215	1·343	1·65	...	0·27	...
	Infested stem	78·7	21·3	0·211	1·318	1·66	...	0·22	...
23 October	Uninfested leaves	78·1	21·9	0·548	3·425	4·79	2·29	1·30	10·09
	Infested leaves	78·5	21·5	0·610	3·812	4·00	2·29	1·11	10·29
	Uninfested stem	74·0	26·0	0·218	1·362	...	...	0·25	...
	Infested stem	80·7	19·3	0·223	1·393	...	...	0·18	...
	Uninfested flower buds, etc.	84·6	15·4	0·352	2·200	0·932	...	0·41	...
	Infested flower buds, etc.	87·0	13·0	0·478	2·987	1·330	...	...	...
6 November	Uninfested leaves	78·5	21·5	0·524	3·275	4·211	2·23	1·29	10·49
	Infested leaves	77·6	22·4	0·574	3·487	3·187	2·03	1·03	12·66
	Uninfested stem	76·7	23·3	0·228	1·425	1·600	...	0·24	...
	Infested stem	75·6	24·4	0·239	1·493	1·561	...	0·21	...
	Uninfested flower buds, etc.	82·3	17·7	0·398	2·487	1·164	4·87	0·72	8·46
	Infested flower buds, etc.	85·2	14·8	0·375	2·343	1·021	1·24	0·41	9·79
29 November	Uninfested leaves	79·7	20·3	0·512	3·200	4·25	2·00	0·80	10·05
	Infested leaves	78·5	21·5	0·608	3·800	4·37	1·83	0·76	10·74
	Uninfested stem	75·1	24·9	0·194	1·212	1·47	...	0·16	...
	Infested stem	79·8	20·2	0·218	1·362	1·99	...	0·16	...
	Uninfested flower buds, etc.	77·8	22·2	0·513	3·206	1·44	7·15	2·08	8·32
	Infested flower buds, etc.	88·0	12·0	0·324	2·025	0·98	2·00	0·34	6·65
12 December	Uninfested leaves	79·8	20·2	0·480	3·000	3·94	2·16	1·08	10·02
	Infested leaves	79·2	20·8	0·584	3·650	3·86	2·41	0·92	9·96
	Uninfested stem	76·7	23·3	0·188	1·175	1·53	...	0·15	...
	Infested stem	80·0	20·0	0·198	1·237	1·46	...	0·14	...
	Uninfested flower buds, etc.	75·3	24·7	0·573	3·581	1·60	0·87	...	...
	Infested flower buds, etc.	...	...	...	...	...	...	...	...

TABLE IV

Statistical analysis of the data in Table III

Constituents	Difference of means : high *minus* low infestation	Standard error of the difference	Values of '*t*'	Remarks
sture . .	—1·18	0·270	4·37*	
ogen (from September onwards)	+0·068	0·011	6·20*	
Before October	+0·462	0·091	5·133*	
From October onwards	—0·432	0·210	2·050	
. . . .	—0·123	0·030	4·124*	
ohydrates .	+1·027	0·229	4·465*	

* Highly significant

ease in fruiting. If nitrogen supply is too low in the tissues, fruit buds not develop or, if developed, will shed.

Carbohydrate-nitrogen ratio varies with different plants. According to [1919], quite the reverse results may be obtained with identical ratios plants of different natures. Carbohydrates and nitrogen compounds uate throughout the growing period. The fluctuation of the carbo-ates, however, is in the reverse order of the nitrogen compounds. Hooker 2] suggests that a lowering of C/N ratio enhances the vegetative growth eas a high ratio induces fruit formation. Dastur and Raut [1935] suggested that C/N ratios are probably the effect rather than the cause fferential vegetative and reproductive growth.

Our investigations have shown that in the beginning of the season the nt of nitrogen is relatively higher in the leaves of the uninfested plants in those infested with white-flies. Johnson [1934] also arrived at ilar conclusion with regard to the injury caused by leaf-hopper (*Empoasca*) to the foliage of *Solanum tuberosum*. From September onwards the itions are reversed which yield statistically significant differences. This sion is brought about probably because a much higher percentage of gen along with mineral ash and fat is transported from the vegetative e reproductive organs in the healthy plants to help in boll formation. ation of various constituents has already been established by other ers. There are two factors concerned in the reproductive phase of a : (*i*) formation or non-formation of bolls and (*ii*) their development or ling. Mason and Maskell [1931] state that fertilization markedly in-es the rate of uptake of phosphorus and total ash as well as of carbo-ates and nitrogen by the ovule. They further point out that removal of

growing bolls is followed by marked increase in the concentration of ash, nitrogen and carbohydrates in the leaves and stem tissues. Such a tion has been noticed as a result of white-fly attack where the bolls ar few and, therefore, some of the constituents actually increase in the v tive regions. Similar view is also expressed by Mason and Phillis [Thus leaf is the main distributing centre of sugars and of mineral materials and gradually the bolls drain the vegetative plant of its food rials ; if the leaves fall off the flowers and bolls are starved and finally Kundrin [1929] also maintains that development of flowers requires creased supply of nitrogen and ash and results in a migration of these c tuents from the vegetative to generative organs. Gregory [1934] refe migration of nitrogen and concludes that after reaching a maximum it l to fall in the leaves and a rapid transference takes place from leaves to l

Thus we conclude :

(*i*) since the healthy plants on the whole produce more of total gen than the infested ones, under exactly similar agricu treatments this difference may be attributed to insect attac result of which the sap of the plant is drained off ;

(*ii*) that the percentage of nitrogen and mineral ash transported the vegetative to the reproductive organs is much hig the uninfested plants, evidently because a healthy plant rich in these materials is in a position to maintain a r and abundant supply of nutrition for the reproductive o The attacked plant, on the other hand, having a meagre has to keep the reproductive organs in an almost starved tion ;

(*iii*) that the adverse effects on the infested plants as seen in formation or dropping of floral buds, etc., may be the res some dislocation in the carbohydrate-protein balance, wh affected by the insect attack.

These factors interacting may upset the normal vegetative and repr tive functioning of a plant. Further, they reduce the floral bud form as well as increase shedding of flowers and bolls and thus result in low and poor development of lint and seed.

2. *Effect of attack on total dry weight of the parts of a plant above soil*

To make an accurate estimate of the relative output and difference be uninfested and infested plants, experiments were designed during 1932, and 1935 to determine the total dry matter produced by plants varied intensities of white-fly attack. Cotton was grown in a big cage di into three compartments, each $16 \cdot 5 \times 16 \cdot 5 \times 8$ ft. In one of these com ments, plants were heavily infested artificially, in another a moderate a was maintained while in the third the plants were kept under low infest which meant that they were almost free from attack.

During 1932 and 1934 two sets of 10 plants each were under ob ation in each of these cages. The relative position of these sets of plant similar in all the cases. A cloth catch-net was fixed under each set to c the material shed by these plants. The material from each set was

d and weighed separately. At the end of the season, however, the weight he stems, capsules, unshed leaves and the *kapas* (seed cotton) picked n the respective sets was similarly determined.

The white-fly infestation in these cages was relatively higher in 1932 than in the other years. It is obvious from the data in Table V that, on an age, the total dry matter produced per plant varied with the intensity ttack, being the highest under least infestation and lowest under severe ck. During 1932, the uninfested plants produced, on an average, 352·6 of dry matter per plant against 191·8 gm. produced by the infested ts. In 1934 the uninfested plants produced, on an average, 407·6 gm. y weight per plant against 315·1 gm. by the infested plants. The average oth the years indicates that the total dry matter produced by the un- ted and infested plants was 380·09 gm. and 253·47 gm. respectively. ; on an average, 49·9 per cent more of dry matter was produced by the fested plants.

An almost corresponding effect was noticed in shedding of leaves, floral and flowers in these plants. Relative shedding was 54·6 per cent in the fested and 55·9 per cent in the infested plants during 1932 and 42·0 ent and 49·4 per cent respectively in 1934.

The effect of white-fly attack on the final yield was still more pronounced. ng 1932, the average yield of *kapas* per plant varied from 58·1 gm. in ninfested to 20·3 gm. in the infested plants, the difference being signi- t. In 1934, however, the corresponding yields were 98·9 gm. and 68·1 espectively (Table VI) and the difference was still significant.

During 1935, the scheme of work was modified with a view to determine ate of growth, of the plant, by noting its dry weight in different months, in on to white-fly infestation.

Observations were made in two cages only. In each cage duplicate sets plants each were marked at corresponding places and catch-nets were under individual sets. The plants in one of these cages were heavily ed with white-fly, while in the other cage they were kept almost free attack.

Duplicate sets were removed every month from each cage during July tober, and the plants were chopped, dried and weighed as previously. The data collected is presented in (Table VII).

Till the end of July the plants under observation grew almost equally h the cages and produced, on an average, about 56·1 gm. of dry matter lant. By the end of August, however, the infested plants produced per cent less of dry weight per plant as compared with the uninfested By the end of September again the infested plants showed 11·1 per ess of dry weight. By the end of October, however, the infested plants pro- 10·8 per cent less of dry matter in the vegetative region and 20·0 per ess in the reproductive organs, as compared with the corresponding s in the uninfested plants. It is, therefore, presumed that the re- n in the vegetative growth of a plant under white-fly attack is brought during the month of August after which it continues almost at the same s in the uninfested plant, but the reproductive organs are seriously ed during the later period.

TABLE V

Relative dry weights produced by the plants under different infestations of B. gossypiperda

Treatment	Number of plants	Set No.	Average infestation per sq. in.	Total weight of shed material (gm.)	Total weight of sticks, leaves and capsules of the plants	Total weight of cotton picked (gm.)	Total dry weight produced (gm.)	Average dry weight per plant (gm.)	Percentage of shedding
1932									
Uninfested	19	A	1·19	1452·20	1105·90	493·85	3051·95	352·61	54·59
		B	...	1602·85	1434·70	610·05	3647·60		
Moderately infested	20	A	5·52	1325·17	1142·60	551·95	3019·72	228·00	56·38
		B		795·41	498·00	246·92	1540·33		
Infested	20	A	11·12	1133·88	964·00	232·40	2330·28	191·84	55·94
		B		784·99	547·20	174·30	1506·49		
1934									
Uninfested	20	A	0·32	1436·1	1869·5	1001·6	4307·2	407·58	4·00
		B		1157·0	1711·3	976·1	3844·4		
Moderately infested	20	A	1·23	1273·8	1212·1	693·0	3178·9	318·92	46·85
		B		1118·5	1501·0	580·1	3199·6		
Infested	20	A	7·50	1277·8	1000·0	512·5	2790·3	315·10	49·41
		B		1163·8	1499·5	848·5	3511·8		
Average									
Uninfested	...	...	...	...	...	...	...	380·09	43·20
Moderately infested	...	...	...	...	...	...	...	273·46	51·62
Infested	...	...	...	...	...	...	...	253·47	52·68
Mean	...	...	...	...	...	...	...	302·34±39·21	50·87±1·2319

TABLE VI

Relative number of bolls and lint weight, etc. on plants under dry weight experiment, 1932 and 1934

Year	Number of plants	Total number of bolls matured	Average number of bolls per plant	Total number of locks picked	Average number of locks per plant	Total weight of *kapas* (gm.)	Average weight per lock	Average weight of *kapas* per plant (gm.)
1932								
Uninfested	19	366	19·3	1373	72·3	103·90	0·804	58·10
Moderately infested . .	20	305	15·3	1169	58·5	798·87	0·683	39·34
Infested . . .	20	169	8·5	657	32·9	406·70	0·618	20·34
Mean .	...	...	14·37±3·152	...	...	...	0·702±0·054	39·26±10·90
1934								
Uninfested	20	710	35·5	2759	137·9	1977·7	0·717	98·88
Moderately infested . .	20	565	28·2	2159	107·9	1273·1	0·589	63·15
Infested	20	508	25·4	1961	98·0	1361·0	0·693	68·05
Mean .	...	...	29·70±3·010	...	...	...	0·666±0·039	76·69±11·18

TABLE VII

Relative dry weight produced by uninfested and infested plants, 1935

Description of the set	Total number of plants examined	Total weight produced by the end of						Remarks
		July (gm.)	August (gm.)	September		October		
				Vegetative portion (gm.)	Reproductive portion (gm.)	Vegetative portion (gm.)	Reproductive portion (gm.)	
Uninfested—								
A	6	408·0	943·0	1627·0	56·5	2650·1	786·8	
B	6	265·0	942·0	...*	...*	2206·0	416·5	* In September only one set of six plants was examined from each cage
Total .	12	673·0	1885·0	1627·0	56·5	4856·1	1203·3	
Average weight per plant .	...	56·1	157·1	271·2	9·4	404·7	100·3	
Infested—								
A	6	470·0	919·5	1446·0	58·5	2226·0	606·9	
B	6	205·0	743·5	...*	...*	2106·5	355·0	
Total .	12	675·0	1663·0	1446·0	58·5	4332·5	961·9	
Average weight per plant .	...	56·2	138·6	241·0	9·7	361·0	80 2	

The above data show conclusively that the uninfested plants produce ively more of total dry material than the infested plants, and are, there- better developed. Thus, the white-fly attack seriously interferes with ormal plant growth whereby the infested plants suffer both with respect eir vegetative and reproductive development. Unhampered vegetative th in the healthy plants, on the other hand, encourages boll action and ultimately affects the yield favourably.

fect and after-effects of the attack

The effect and after-effects of the white-fly attack on the vegetative h of cotton plants and, subsequently, their capacity for producing flowers olls were investigated under various intensities of attack.

Experiments by Husain and Trehan [1933] were further modified and arious effects of severe infestation for a month's duration at different ls of plant growth were studied.

For these observations plants were grown under cages 6 ft. × 6 ft. × 6 ft. or 9 ft. × 6 ft. Except the plants which were kept almost free from infesta- or under moderate attack throughout the season, each set was exposed to ere white-fly attack for the required period. Before and after this period, ver, the plants were kept free as far as possible by 'hand picking' and onal sprayings if necessary.

The plants grown under cages behaved slightly differently from those out fields, but the results obtained under almost identical conditions were urable. The following sets were under observation each year from o 1936 :

Practically free from attack. Four to fifteen plants were under observ- The plants grew exceedingly well and were very bushy. The number ves and the height attained by the individual plants were invariably aximum as compared with those of the other sets.

Normal infestation during the season. Observations were made on four rteen plants. An infestation approximating that in the field was ained every year and at times the adults were 'hand picked' and ed if multiplication appeared excessive. Although attempts were to keep the attack under control, it appeared slightly higher than utside. The plants grew normally but some of the middle and bottom turned black by September and ultimately became flaccid and drooping.

Heavy infestation during July only. Observations were made on four teen plants. After a severe infestation for one month, the adults were ed in August and the plants thoroughly sprayed. Spraying was repeated few days to ensure complete freedom from attack. During the period station, growth of the plants was hampered considerably. The leaves black and drooped down. When the attack was removed by 'hand g' and spraying after the specified period, the plants recovered very well most regained their normal size and shape.

Heavy infestation from 15 July to 15 August. The number of plants this treatment ranged from eight to twelve. Till about the third week the plants grew very well but after that they received a severe set-back. the period of heavy infestation, the leaves turned black and most of

them drooped down, the growth was almost checked and the plants ap sickly. During 1934 the plants were so badly affected that they coul recover even after the attack was removed.

Heavy infestation during August only. Four to eight plants under observation during 1931, 1934 and 1935. The plants behave satisfactorily till about the first week of August after which they very sickly and most of the middle and bottom leaves showed the chara tic signs of damage. The growth was almost at stand still and some bottom leaves reddened and dried up prematurely and were ultimately

Severe attack from middle of August to middle of September. observations were carried out from 1932 onward and six to eight plant put under this treatment every year. In the first year the attack was tained from 7 August to 9 September, but in the subsequent years the ation extended from 15 August to 15 September. In general, the attained a good growth before they were exposed to attack, but during ation period they appeared sickly and the bottom leaves were shed con tively very early.

Severe attack throughout the season. This set was maintained o 1931. The plants grew though not normally since almost all the leav turned black and drooped (Plate XXXI, fig. 1). Premature shedding of and floral buds was also a conspicuous feature.

i. *Effect of the attack on growth of a plant.* Series of observations made on the extent of growth in plants under respective sets. Weekly me ments of the main stem of individual plants were recorded for abou months commencing from the 1st of July each year.

These observations showed that during the period of heavy attac vegetative growth is checked considerably (Table VIII) and in certain it may be almost stopped. The leaves produced are relatively fewer in n and smaller in size than those on the uninfested plants. The floral buds yellow and drop off. Thus, during the period of attack, the growth is af very badly in all respects. If the attack is removed during the growing p the plants can recover and regain their growth, and in such cases the may even resume their normal size. The minimum growth was noticed the plants were under heavy infestation from the middle of July to the e August. Comparing the uninfested plants with (1) infested from 1 to 31 and (2) moderately attacked sets which were common in all the three the increase in height of the main stem differed significantly in the forme approached quite near the significance in the latter case.

Further, the detrimental effect of the white-fly attack, as is manifest arresting the vegetative growth, gets prominent about a week to 10 days the infestation has commenced. Moreover, the same effect is continue almost the same period even after the attack is removed. This effect is clear from the conspicuous bends which are seen in Fig. 1. Plants least infestation or those where moderate infestation was maintained tinued to grow normally.

ii. *After-effects of attack on flower and boll formation.* In nature white-fly attack on cotton, subsides from September onward whereas th formation starts from about the middle of August and continues right

FIG. 1. Cotton plants under severe white-fly infestation

FIG. 2. Cotton plants practically free from white-fly infestation

TABLE VIII

Relative increase in height of plants under severe infestation of B. gossypiperda *at different periods of their growth*

Description of plants	Average height of plants to start with	Average increase in height during				Total average height attained	Average increase in height	Remarks
		July	August	September	October			
1931	ft. in.	in.	in.	in.	in.	ft. in.	ft. in.	
Uninfested	1 8	9·8	10·8	17·3	3·3	5 1·2	3 5·2	
Moderately infested	1 4	8·6	9·1	12·6	3·5	4 1·8	2 9·8	
Infested from 1 to 31 July	2 2·5	2·7	4·8	7·5	5·5	3 11·0	1 8·5	
Infested from 1 to 31 August	2 0·8	5·2	2·0	3·2	3·0	3 2·2	1 1·4	
1932								
Uninfested	1 3	9·5	20·3	26·5	...	5 11·3	4 8·3	Observations upto September only
Moderately infested	2 0	8·5	10·5	19·3	...	5 2·3	3 2·3	
Infested from 1 to 31 July	1 9	7·0	7·1	25·5	...	5 0·6	3 3·6	
Infested from 15 July to 15 August	1 8	13·0	5·5	11·0	...	4 1·5	2 5·5	
Infested from 7 August to 9 September	1 9	13·3	22·3	7·0	...	5 3·6	3 6·6	
1933								
Uninfested	0 7·6	4·2	15·7	21·4	...	4 1·0	3 5·4	Under moderate infestation up to 5 August 1933 and least infestation after that
Moderately infested	1 7·2	3·0	7·3	15·0	...	3 8·5	2 1·3	
Infested from 1 to 31 July	2 2·6	0·5	10·6	24·3	...	5 2·0	2 11·4	
Infested from 15 July to 15 August	1 9·6	1·6	5·7	18·4	...	3 11·3	2 1·7	
Infested from 15 August to 15 September	1 2·1	3·5	15·1	8·3	...	3 5·0	2 2·9	

Table IX

Flower and boll record on plants under different infestations of B. gossypiperda, *1931-35*

Treatment	Year	Infestation		Total number of flowers opened	Total number of flowers and bolls shed	Percentage of shedding	Total number of bolls matured	Average number of bolls per plant	Total number of locks picked	Total number of locks opened bad	Percentage of bad opening		Remarks
		Average attack during the period of infestation	Average attack during the rest of the period										
Uninfested	1931	0·19	0·19	381	201	52·7	180	30·0	...	...	7·8	Six plants	During 1933, plants under least infestation were kept from 6 August onwards. Those plants, therefore, were not included in this statement
	1932	0·60	0·60	337	150	44·5	187	46·7	748	23	3·1	Four plants	
	1934	0·20	0·20	1401	732	52·2	669	66·9	2563	371	14·5	Ten plants	
	1935	0·76	0·76	463	245	52·9	218	14·5	883	258	30·3	Fifteen plants	
	Average for 1932, 1934 & 1935	0·52	0·52			49·87		42·70			15·97		
Moderately infested	1931	16·30	16·30	152	87	57·2	65	10·8	...	...	52·3	Six plants	
	1932	6·59	6·59	249	135	54·2	114	28·5	456	221	48·4	Four plants	
	1933	5·55	5·55	200	134	64·3	66	16·5	230	119	51·7	Four plants	
	1934	8·40	3·40	235	149	63·4	86	21·5	341	114	33·4	Fourteen plants	
	1935	2·07	2·07	241	122	50·6	119	8·5	453	187	43·5		
	Average	7·78	7·78			56·07		19·50			41·77		
Infested from 1 to 31 July	1931	...	...	89	58	65·1	31	15·5	...	...	64·5	Four plants	Two died
	1932	19·51	1·28	365	196	53·7	169	21·1	667	187	28·0	Eight plants	
	1933	38·85	0·62	790	399	50·4	391	48·9	1576	219	13·9	Eight plants	
	1934	82·20	2·22	566	263	46·4	303	37·7	1211	263	21·7	Nine plants	
	1935	25·87	1·30	344	201	58·4	143	11·0	541	208	38·4	Thirteen plants	
	Average	41·63	1·35			52·83		23·27			29·37		
Infested from 15 July to 15 August	1932	22·98	0·65	425	266	62·6	159	19·9	621	291	46·8	Eight plants	
	1933	20·80	1·03	479	274	57·2	205	25·6	709	356	50·2	Eight plants	
	1934	32·11	4·02	252	136	53·9	116	14·5	462	239	51·7	Eight plants	
	1935	63·65	7·31	160	100	62·5	60	5·0	222	161	72·5	Twelve plants	Attack increased considerably
	Average	34·89	3·25			59·70		13·13			57·00		
Infested from 1 to 31 August	1931	76·30	0·06	55	42	76·4	13	6·5	...	...	69·2	Four plants	Two died
	1934	40·08	0·40	231	122	52·8	109	13·6	432	204	47·2	Eight plants	
	1935	55·89	0·78	489	253	51·8	236	29·5	914	158	17·2	Eight plants	

Infested from 1st August to ...	1934	13·09	0·83	232	120	51·7	112	16·0	449	165	36·8	Six plants
	1935	12·40	0·59	315	199	63·1	116	19·3	448	67	15·0	Seven plants Six plants
	Average	15·57	0·66			60·97		18·10			37·10	
Infested severely throughout .	1931	68·00	68·00	49	30	76·9	9	4·5	...	...	78·8	Four plants
	1932	27·87	27·87	3	3	100·0	...	...	...	...	...	Four plants
	1933	29·00	29·00	...	...	...	...	...	...	...	...	Four plants
	Average	41·62	41·62									
S. E.						±3·825		±6·512			±8·698	
Critical difference—												
5 per cent . . .						12·474		21·237			28·365	
1 per cent . . .						18·148		30·897			41·269	

Two died. Once sprayed by mistake. Infestation from August onwards. No flower appeared	

N.B.—Analysis of the data for 1932, 1934 and 1935 only

the end of October. Does the white-fly leave a permanent effect on its h and if so, what are the results of such an after-effect ? To ascertain th results, plants were artificially infested with the white-flies during differ periods of their growth as previously described, and flower and boll format recorded (Table IX and Fig. 2). Since all the treatments were not uniform represented during 1931 and 1933, the data for 1932, 1934 and 1935 only w analysed statistically.

The following aspects of the problem were studied :

(*a*) *Shedding of flowers and bolls.* The lowest percentage shedding flowers and bolls was noticed in the plants kept almost free from attack d ing the season. The plants heavily infested during the month of J showed an increased shedding of about 3 per cent and those under moder attack 6·2 per cent, as compared with that of the uninfested plants. Simil ly in the plants infested from 15 July to 15 August, and 15 August to September the shedding was increased by 9·8 and 11·1 per cent respectiv Plants maintained under severe infestation throughout the season could be compared because of their very poor condition in this respect.

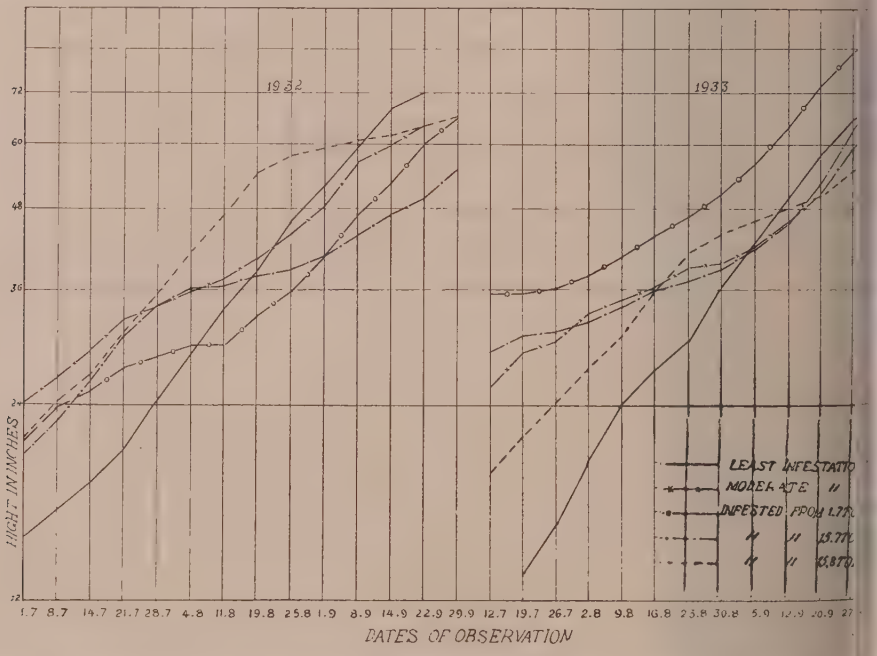

FIG. 1. Height of cotton plants under infestation of *B. gossypiperda* at different peri of growth

Thus, the percentage of shedding in flowers and bolls increased with t intensity of attack, varying, of course, with the period of infestation. Ap from the plants kept under least infestation, the minimum shedding w noticed in the plants infested only during July and maximum in those infest from the middle of August to middle of September. The differences, ho ever, are not statistically significant.

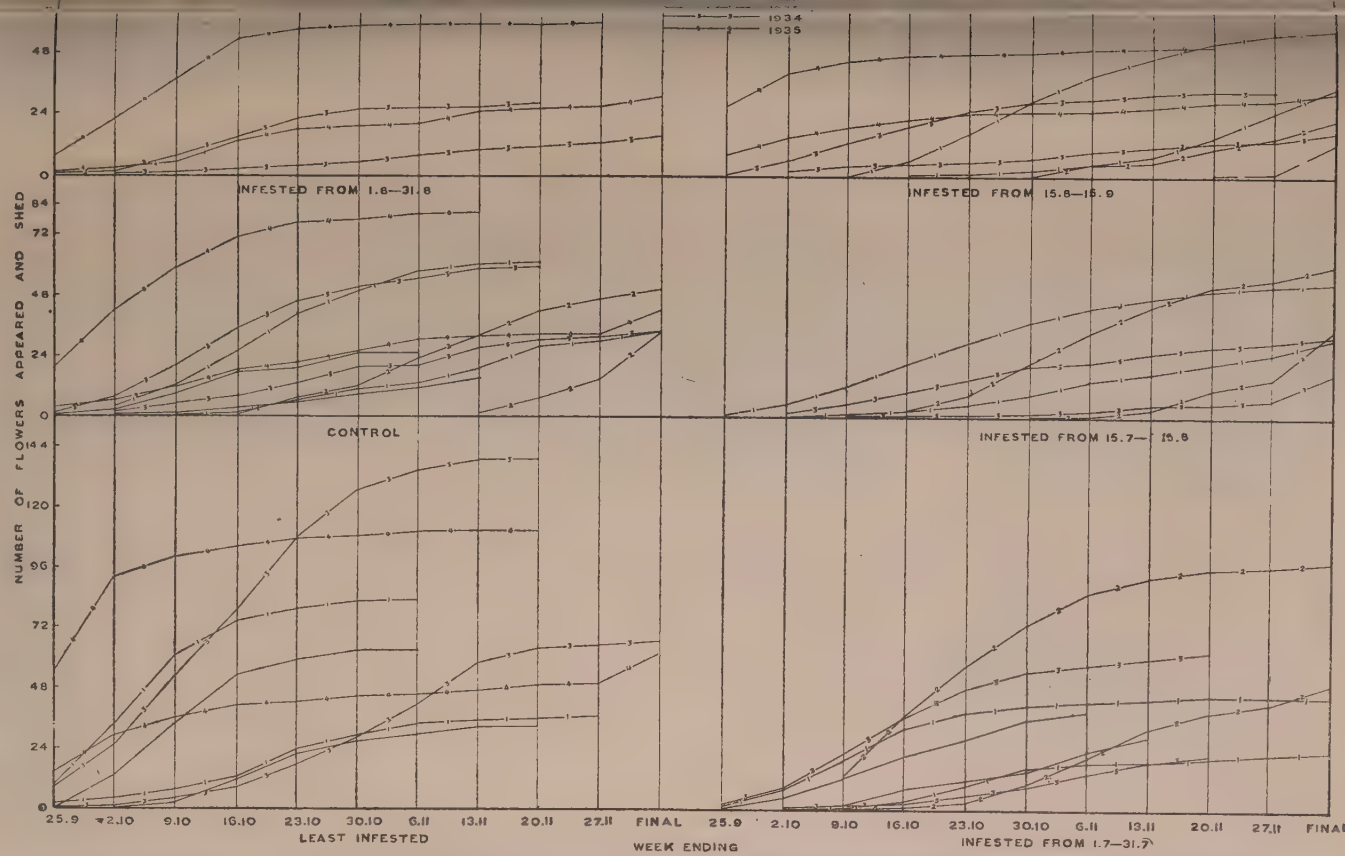

FIG. 2. Total No. of flowers appeared and shed per plant under different infestations of *B. gossypiperda* 1931-35
(Upper lines — flowers appeared
Lower lines — flowers and bolls shed)

(*b*) *Number of bolls matured per plant.* The maximum number of l matured per plant was observed on the uninfested plants (Plate XXXI, fig When comparing the relative bearing on other sets with that on the infested plants, the number of bolls per plant, on an average, was 19·4, 2 29·6 and 24·6 lower on those infested from 1 to 31 July, under mode attack, 15 July to 15 August and 15 August to 15 September respectiv The statistical analysis indicates that the last three infestations hav significant effect on lowering the number of bolls per plant.

(*c*) *Bad opening of bolls.* Corresponding to the above results, the centage of bad opening was almost in the reverse order. The lowest centage of bad opening was observed in the bolls from the uninfested pla The relative figures of all the above-stated sets of plants showed that bad opening was higher by 13·4, 25·8, 41·0 and 21·1 per cent respectiv as compared with that of the least infested plants and the difference betw the uninfested and infested from 15 July to 15 August was statistic significant.

iii. *After-effects of attack on lint and seed development.* The data f these observations are given in Table X, with their statistical analysis Table XI. Since all the treatments were not represented in 1931, the data 1932 to 1935 were examined and the analysis of variance for the diffe characters is given in Table XI. The effect of treatments was signific for average lint per plant and average weight of lint per seed. On splitting the four degrees of freedom for treatments it was found that the two grou A and B (Table XI), differed significantly for all the characters given in table. It may be pointed out that the plants infested from 1 July to 31 which were included in group A behaved very near to the uninfested pla because infestation during the early period of growth did not produce marked after-effects on the development and production of the plants w the attack was removed subsequently.

The mean variance for between groups was tested to the pooled e variance if the differences between the two components of error correspon to between groups and remainder were non-significant. In the case of average weight of lint per seed the error components differed significant hence the variance due to groups was tested against its own error. variance for within A and B groups did not differ significantly. The follow conclusions have been drawn :

i. *Average weight of* kapas *per plant.* The maximum production *kapas* was obtained from the plants kept almost free from attack. The pla which suffered from a moderate attack produced only 44·4 per cent of weight while those infested from 1 to 31 July, 15 July to 15 August 15 August to 15 September produced 51·3, 31·2 and 27·7 per cent respectiv as compared with the uninfested plants and the differences were highly si ficant between the two groups.

Since the development of bolls is judged by the condition of the locks. average weight of *kapas* produced per plant was further calculated with res to the number of locks. This showed that the locks of the uninfested pla and those of the plants infested during July only yielded relatively more *kapas* per lock as compared with plants treated otherwise. Average weigh lint per lock also behaved correspondingly.

Lint and seed record of the plants under different infestations of B. gossypiperda *for the years 1932 to 1935*

Treatment	Year	Total number of bolls picked	Total number of locks	Average number of locks per boll	Total weight of *kapas* (gm.)	Average weight of *kapas* per lock (gm.)	Average weight per *kapas* plant (gm.)	Total number of seeds	Average number of seeds per plant	Average number of seeds per boll	Average number of seed per lock	Total weight of lint (gm.)	Average lint per plant (gm.)	Average lint per boll (gm.)	Average lint per lock (gm.)	Average weight of lint per seed (gm.)	Average weight of single seed (gm.)	Average weight of 200 seeds (average of 5 lots) (gm.)
Uninfested	1932	187	748	4·000	412·20	0·55	103·00	4300	1075·0	23·0	5·74	129·20	32·30	0·61	0·172	0·030	0·065	12·87
	1933	85	316	3·719	204·89	0·65	51·22	1784	446·0	21·0	5·60	59·77	14·93	0·70	0·189	0·033	0·080	16·87
	1934	669	2563	3·831	883·30	0·34	88·33	9079	907·9	13·6	3·54	284·00	28·40	0·42	0·111	0·031	0·066	12·72
	1935	218	883	4·050	390·50	0·44	26·00	4491	299·4	20·6	5·09	129·00	8·60	0·59	0·146	0·028	0·056	11·80
Average for 1932, 1933, 1934 and 1935						0·495	67·14		682·1				21·06		0·155	0·0305		13·57
Infested from 1 to 31 July	1932	169	667	3·946	331·90	0·49	41·5	3656	457·0	21·6	5·50	101·90	12·74	0·60	0·154	0·028	0·064	11·54
	1933	391	1576	4·030	965·33	0·61	120·9	8944	1118·0	22·9	5·65	289·75	36·22	0·74	0·183	0·032	0·073	14·42
	1934	303	1211	3·999	630·00	0·52	70·0	6895	766·1	22·7	5·69	186·00	20·67	0·61	0·153	0·027	0·064	13·66
	1935	143	541	3·837	271·50	0·50	20·9	3219	247·6	22·5	5·95	90·50	6·96	0·63	0·167	0·028	0·055	11·70
						0·530	63·33		647·2				19·15		0·164	0·0288		12·83
Infested from 15 July to 15 August	1932	159	621	3·905	289·72	0·46	36·21	3364	420·5	21·2	5·41	84·44	10·55	0·53	0·138	0·025	0·060	11·03
	1933	205	709	3·459	272·70	0·38	34·09	3665	458·1	17·9	5·10	78·58	9·82	0·38	0·109	0·021	0·051	10·59
	1934	116	462	3·982	171·00	0·37	21·40	2048	251·0	17·3	4·34	43·00	5·38	0·37	0·093	0·021	0·060	12·63
	1935	60	222	3·700	66·50	0·30	5·50	800	66·7	13·3	3·60	20·50	1·71	0·34	0·092	0·025	0·051	8·45
						0·378	24·30		299·1				6·87		0·108	0·023		10·68
Moderately infested	1932	144	456	4·000	168·00	0·37	42·00	2320	580·0	20·3	5·08	48·11	12·10	0·42	0·106	0·021	0·050	10·16
	1933	66	230	3·484	81·22	0·35	20·30	1065	266·2	16·1	4·63	23·53	5·88	0·35	0·102	0·022	0·051	10·32
	1934	86	341	3·965	130·00	0·38	32·50	1745	436·3	20·3	5·13	35·00	8·75	0·40	0·102	0·020	0·054	10·61
	1935	119	453	3·803	184·00	0·40	13·16	2316	165·4	19·5	5·11	58·50	4·17	0·49	0·129	0·025	0·052	10·62
						0·375	26·98		362·0				7·73		0·110	0·0220		10·43
Infested from 1 to 31 August	1934	109	432	3·993	137·00	0·31	17·10	1987	248·4	18·2	4·60	38·25	4·78	0·35	0·088	0·019	0·048	11·23
	1935	286	914	3·872	419·40	0·45	51·30	4396	549·5	18·6	4·81	129·4	16·17	0·55	0·141	0·029	0·062	12·58
Infested from 15 August to 15 September	1932	152	600	3·947	200·59	0·33	25·07	2834	354·3	18·6	4·63	56·88	7·11	0·37	0·095	0·020	0·049	9·63
	1933	30	92	3·066	20·80	0·23	3·47	323	80·8	10·8	3·51	5·41	1·35	0·18	0·059	0·016	0·041	8·46
	1934	112	449	4·009	139·00	0·31	19·86	2151	307·3	19·2	4·77	47·00	5·88	0·36	0·105	0·022	0·045	9·39
	1935	116	448	3·862	228·80	0·51	38·10	2188	364·7	18·8	4·88	60·90	10·15	0·52	0·136	0·027	0·073	15·24
						0·345	21·63		276·8				6·12		0·095	0·0205		10·68
S. E.						±0·04737	±13·176					±3·951		±0·001442			±1·078	
Critical differences— 5 per cent						0·1460	40·602					12·176		0·004444			3·3228	
1 per cent						0·2047	56·925					17·071		0·006230			4·6586	

TABLE XI

Statistical analysis of the data in Table X

Sources of variation	D.F.	Average weight of *kapas* per plant			Average weight of *kapas* per lock			Average lint per plant			Average weight of lint per seed			Average weight of 200 seeds		
		S.S.	M.S.	F.	S.S.	M.S.	F.	S.S.	M.S.	F.	S.S.	M.S.	F.	S.S.	M.S.	F.
Total	19	19,153·5298	...	...	0·2275	...	...	1832·6112	...	...	0·0004329	...	...	92·7197	...	...
Years	3	2,691·8463	897·2821	...	0·0115	0·00383	...	234·4322	78·1441	...	0·0000229	0·00000763	...	3·1357	...	...
Treatments	4	8,128·0780	2,032·019	2·926	0·1083	0·0271	3·019	848·8248	212·2062	3·398	0·0003102	0·00007755	9·332	33·778	8·4446	1·816
Between groups (A and B)	1	8,041·7629	8041·7629	11·5797†	0·1033	0·1033	11·510†	836·3521	836·3521	13·393 †	0·0002913	0·0002913	12·681 *	32·531	32·531	6·995 *
within A group	1	29·0700	29·0700	...	0·0024	0·0024	...	7·2962	7·2962	...	0·0000062	0·0000062	...	1·081	1·081	...
within B group	2	57·2450	28·6225	...	0·0026	0·0013	...	5·1765	2·5883	...	0·0000127	0·0000064	...	0·167	0·0835	...
Error . .	12	8,333·6055	694·4671	...	0·1077	0·008975	...	749·3542	62·4462	...	0·0000998	0·000008317	...	55·8056	4·6505	...
Error for between groups	3	2,624·8286	874·943	N S.	0·0457	0·01523	N. S.	219·3746	73·1249	N. S.	0·0000689	0·00002297	S.	19·6235	6·5412	N. S.
	9	5,708·7769	634·308		0·0620	0·00689	...	529·9796	58·8866		0·0000309	0·00000343		36·1821	4·0202	

N. B.—Group 'A' indicates plants uninfested and those infested for 1 July—31 July. Group 'B' indicates the remaining three sets taken together

* Significant
† Highly Significant
S. Significant
N. S. Non Significant

ii. *Average number of seeds and weight of lint per plant.* Corresponding to the weight of *kapas*, the seed and lint per plant were also affected according to the intensity of attack and the period of infestation.

Further, seed weight was estimated from 1,000 seeds from each set in five lots of 200 each. The seeds from the uninfested plants, on the whole, yielded higher weight as compared with other sets.

It is, therefore, observed (Table XI) that the relative production of both these factors, namely seed and lint per plant and weight of seed, are seriously affected by the white-fly attack. Their relative values, however, indicate that the average weight of lint per seed is affected rather adversely and the differences are highly significant.

Results of considerable interest were obtained when the relative development of lint and seed per lock was compared with that of the control plants. In this way the actual production in various sets was judged on the basis of the expected one which was likely to be produced under normal conditions of attack as shown in Table XII. Thus, it was estimated that the bolls from the uninfested plants produced about 33·3 per cent more of lint and 25·7 per cent less of seed than what they were expected to produce under normal conditions. Similarly the lint produced by the plants heavily infested from 1 to 31 July, 15 July to 15 August and 1 to 31 August was 23·1 per cent, 2·5 per cent and 1·6 per cent higher respectively whereas it was lower when the infestation extended from 15 August to 15 September. The seed weight on the contrary showed the reverse order.

Since it has been observed that the white-fly attack is detrimental in all respects, it is evident that the cotton plant suffers more or less in all its phases. The above data, however, have shown that comparatively more damage is brought about if the attack appears in the latter part of the growing period. This obviously is within expectation, because during that critical period most important changes and adjustments in the vital nutrients take place in the plant tissue and any disturbance during the flowering period or little before it is likely to act adversely on the subsequent yield.

White-fly and the leaf curl of cotton and zinnia. Mathur [1933] states that *B. gossypiperda* is responsible for producing leaf crinkle in zinnias at Dehra Dun. He further remarked that the leaf crinkle of cotton in the Sudan was identical with that in zinnia at Dehra Dun, the vector being the same.

There is no leaf crinkle of cotton in the Punjab, but a disease called the 'smalling disease' of cotton is common in certain localities of the province.

To study the rôle of *B. gossypiperda* in causing the so-called 'smalling disease' of cotton or the leaf curl in zinnias, some observations were made during 1932 and 1933 and the following scheme was adopted :

1. Adults of *B. gossypiperda* were collected from malformed leaves of zinnia and dwarf plants of cotton in nature and were sleeved on to healthy seedlings of cotton and on zinnia.

2. Adults of *B. gossypiperda* which emerged from the nymphs bred on malformed leaves of zinnia or on cotton plants suffering from 'smalling disease' were liberated on healthy seedlings of cotton and zinnia.

In both cases no crinkling was produced on zinnia and no smalling or crinkling on cotton. The results of these observations are given in Table XIII.

TABLE XII

Development of lint and seed under varied white-fly infestation, in relation to the production under moderate attack

Sets under comparison	Weight of lint per boll (Average of all years) (gm.)	Number of seeds per boll (Average of all years)	Lint expected on the basis of the number of seeds (gm.)	Difference between the actual production and the expected	Number of seeds expected on the basis of the observed lint weight	Difference between the actual production and the expected	Percentage of increase or decrease in the lint produced	Percentage of increase or decrease in the seeds produced
Uninfested	0·60	19·3	0·45	+0·15	26·0	—6·7	+33·3*	—25·7
Moderately infested	0·44	19·0						
Infested from 1 July to 31 July	0·64	22·4	0·52	+0·12	27·6	—5·2	+23·1	—18·8
Moderately infested	0·44	19·0						
Infested from 15 July to 15 August	0·41	17·4	0·40	+0·01	17·7	—0·3	+2·5	—1·7
Moderately infested	0·44	19·0						
Infested from 1 August to 31 August	0·45	18·4	0·43	+0·02	19·4	—1·0	+4·6	—5·1
Moderately infested	0·44	19·0						
Infested from 15 August to 15 September	0·36	16·9	0·39	—0·03	15·5	+1·4	—7·7	+9·0
Moderately infested	0·44	19·0						

\+ Indicates increase
— Indicates decrease

N. B.—(*i*) The normal lint value is the average weight of lint per seed of the moderately infested $= \frac{0·44}{19·0} = 0·0232$ gm. and the expected value for other treatments are obtained by multiplying the number of seeds with this factor

(*ii*) The normal number of seeds is obtained from the moderately infested treatment corresponding to unit lint $\frac{19·0}{44·0} = \frac{1}{0·0232}$ and the corresponding expected number of seeds are obtained by multiplying the amount of lint with this factor

TABLE XIII

egative results in the transmission of leaf curl disease by B. gossypiperda *in the Punjab*

Date	Number of adults liberated	Adults bred or collected from	Plants on which adults liberated	Number of leaves on the plant	New adults emerged on	Remarks
1932						
August .	Numerous	Cotton plant with 'smalling'	Cotton .	...	21 September 1932	No crinkling. Second generation also completed by 12 December 1932
September.	16	Bred on cotton plant with 'smalling'	Do. .	3	12 October 1932	No crinkling. New and the old leaves normal
	17	Do. .	Do. .	5	Do. .	Do.
	23	Do. .	Do. .	4	Do. .	Do.
	22	Do. .	Do. .	4	Do. .	Do.
	15	Collected from zinnia	Do. .	5	Do. .	Do.
	13	Do. .	Do. .	4	Do. .	Do.
	25	Do. .	Do. .	4	Do. .	Do.
	Numerous	From those emerged on 21 September 1932	Do. .	...	Do. .	Very severe infestation of nymphs, etc, but no crinkling up to 12 October 1932
1933						
ugust .	Numerous adults	On cotton plants in a cage	Zinnia .	Four plants	...	The plants were kept in a cage where cotton plants were very severely infested by the white-fly. Zinnia plants were severely infested but no crinkling was observed till 8 October 1933. In one plant, however, the top leaves showed some malformation. New leaves were quite normal
vember .	7	Bred on cotton plant with 'smalling'	Do. .	One plant with four leaves	...	By 15 October, the number of leaves increased to 12. When the sleeve was removed the smaller leaves were found a little crumbled
tember	12	Do. .	Cotton .	3	...	The plant grew nicely upto 4 October and the leaves were quite normal. The plant died on 6 October 1933
tember.	8	Do. .	Do. .	3	...	Both the plants grew quite healthy when they were kept under observation till 14 November 1933
.	6	Do. .	Do. .	3	...	

The data presented above are meagre and it is not very safe to draw any usive statement. It may, however, be pointed out that *B. gossypiperda* not given any indication of being the direct cause of producing the ling or the 'smalling' disease in zinnia or cotton respectively in the ab. Further, the abundance of the white-fly and corresponding absence

of any pathogenic disease even in zinnia plants which were enclosed in cage and thus exposed to severe infestation by this pest excludes all possibilitie of its being the transmitter of such a disease. The plants under observatio were kept in those cages for about 45 days, but symptoms of disease wer not noticed. In one case only the top leaves showed a little malformation This was probably the result of very high infestation and a consequen desapping of the foliage.

These investigations show that the causative organism of leaf crinkle c the Sudan may very likely be absent in the white-flies of this province or a least it is not so virulent here. This conclusion is supported by the views c Butler [1934] who states ' The leaf curl in the Sudan was like malaria requi ing both the insect and the parasite. Position in the Punjab where white-fl is abundant and leaf curl rare is exactly the same as in England whe anophales occurred but no malaria as there were no parasites '. Jackson [193 suggests ' Leaf roll was a physiological effect not associated with any pes though an insect might be attracted by the sap condition arising out of th physiological state of the plant. '

Some results of our cage experiments during 1931 and again in 1934 ma elucidate our contention and support the views expressed above. In a fe plants which were artificially kept almost free from white-fly attack during t season, ' smalling ' of leaves and branches appeared on some of the branch whereas those under severe infestation were quite free from these symptoms.

This disease, however, has not been regarded of hereditary nature b Mohammad Afzal [1935].

It is, therefore, presumed, as already pointed out by Husain [1930], th *B. gossypiperda* may not be regarded, so far, as a vector for the transmissi of this disease in cottons or even in zinnia in the Punjab. However, t problem should be taken up more seriously since there is every possibility the introduction of such diseases in the province as this white-fly has be proved by other workers to be the carrier of the leaf-curl virus in other parts the country.

Summary

The nature of damage by Aleurodidae has not been rightly understood far. The present investigations, therefore, were undertaken to analyse t various aspects of this problem.

In the absence of any mechanical injury to the plant tissues, the effe of the white-fly attack were studied in relation to the physiological changes the plant, its rate of growth and its reproductive activities.

The percentage of moisture is relatively higher in the uninfested pla with a corresponding increase of dry matter in the infested ones. Healt plants show a lower C/N ratio—a condition that has been shown to stimul the vegetative and reproductive growth of the plant.

Nitrogen is higher in the foliage of the uninfested cotton plants till t middle of August, after which it may rise in the foliage of the infested pla However, it is significantly higher in the bolls of the uninfested plants than those of the infested ones.

A much higher percentage of nitrogen, ash and fat is transported from the egetative to the reproductive organs in the uninfested plants.

Reduction of bolls on the infested plants may be the result of some dis-ocation in the carbohydrate and protein balance.

The total dry matter produced by the uninfested plants as a result of their rowth far exceeds that produced by the infested ones and, on an average, may xtend to about 40 per cent. Thus the vegetative and reproductive growths re superior in the case of uninfested plants.

During the period of severe infestation, the vegetative growth is checked nd in severe cases of attack may be almost stopped.

The boll formation increases as the intensity of attack decreases while ie shedding and bad opening of the bolls correspond with the increase in ttack. The bolls produced by the uninfested plants are well developed, and ield a maximum weight of *kapas*. The severity of infestation particularly hen it appears late in the growing season lowers the yield of lint and affects ie plant more adversely in all respects.

B. gossypiperda has not been found in any way responsible for the trans-ission of the 'smalling' disease in cottons or the leaf-curl in zinnia in ie Punjab.

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SAMPLING OF SUGARCANE FOR CHEMICAL ANALYSIS.

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IN the first paper on the subject, the authors [1937] presented data w could be used to determine the size of the sample of sugarcane w would give analytical figures lying within the limits of accuracy desire the investigator. It was shown that for ordinary analysis of sugar juice, a sample consisting of ten stools picked at random from the field of an acre in size) will give as accurate results as may be required in ro analysis. If, however, the results are to be expressed as percentages on one must have an accurate estimate of the juice per cent, and for this pose a sample consisting of 25 stools was recommended.

The above conclusions were arrived at from a study of the data per ing to Co 318 grown at Lyallpur during the season 1935-36. It was h that later on it would be possible to examine these conclusions with refe to other varieties grown at different stations and to find out the exte which data collected subsequently would bear out the conclusions alr reported.

With the above objects in view, the investigation was extended to a ber of varieties grown at different stations, and in order to study the sea effect, the canes at most of the places were analysed on different dates d the crushing season.

Further, it has been suggested that for any particular limit of accu desired, the size of the sampling unit will depend upon the degree of mat of the cane, i.e., the more mature the cane, the less will be the number of or cane units required to make up the sampling unit. In other words ke the size of the sampling units the same, the degree of accuracy obtai will increase with advance in the crushing season. This suggestion required examination.

The investigation, the results of which are presented in the p paper, was carried out during the season 1936-37 and relates to the s cane crop grown under zemindari conditions.

The different varieties of sugarcane selected were analysed three t times during the crushing season, as shown in the following statement :

Locality	Varieties	Date of analysis
ıllpur . .	Co 223, Co 285, Co 312, Co 313	16 December 1936, 27 January 1937, 3 March 1937, 9 April 1937
rdaspur . .	Co 213, Co 285, Co 300, Co 312, Co 331	30 November 1936, 26 January 1937, 12 March 1937
ntgomery . .	Co 223, Co 285, Co 290, Co 312	9 November 1936, 28 January 1937, 13 March 1937 (Only Co 223)
walpindi . .	Katha, Co 285, Co 312 . .	21 December 1936

Size of the sample unit. In the first paper of the series the size of the ıple recommended was ten stools but as this recommendation was based the analytical data relating to only one variety, it could not be stated ınitely that it would apply to all the varieties commonly grown in the ıjab. It was considered likely that in the case of certain varieties a ıller-sized sample may do as well, while in the case of others, larger ıples may be required. In the present investigation, therefore, the size the sample unit was fixed at five stools, since if and when required sample ıes of bigger sizes could be easily constructed from this.

Since the publication of the first paper of this series Arceneaux *et al.* 39] published the results of their investigation on the relation between the of the sample and the experimental error in the analysis of juice and the ermination of the yield of sugar in connection with their sugarcane variety ls. They reported and compared two sets of errors arrived at in two erent ways. The figures for average brix and sucrose percentage in juice e obtained from six replicate samples of 3, 5, 10, 20 and 40 stalks. One of errors was obtained by analysing independently the data pertaining ach one of the six sampling units in all the five sample series. The other of errors, however, was derived by dividing the standard deviation of the st-sized sample series by $\sqrt{n}$, where n denotes the multiple of the lowest- sample corresponding to the larger size for which the error was to be ked out. In this case the multiples used were 5/3, 10/3, 20/3, and 40/3. a result of this investigation, the above authors concluded that although e was a consistent decrease in the standard error of the average differ- with an increase in the number of stalks per sample, yet these figures he observed decrease fell short of those for the theoretical values which obtained on the assumption of complete randomness of variation between three stalk samples. They explained the difference in the two sets of es to be probably due to plot differences in their varietal test. The its obtained by Holmes and O'Neal [1939], on the other hand, showed a close agreement between the two sets of errors worked out as described e.

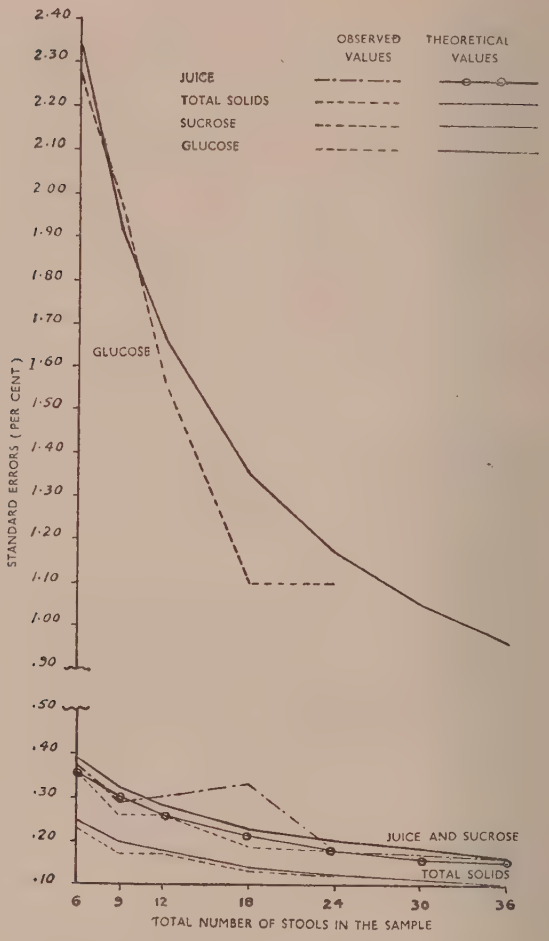

FIG. 1. Observed and theoretical standard errors per cent for Co 318, Lyallp

As mentioned already, we had in view the construction of sample of 10 or even 15 stool size from the lowest-sized sample series, viz., th five stools but before selecting one of the two methods described a it was considered desirable to examine them with reference to the obtained at Lyallpur. Therefore, the values of the standard deviatio different constituents of cane for three stool sample series of Co 318 pres in Table IV of part I of the series [1936] have been used for calculati the second method described above, the standard deviations for sample consisting of sampling units of 6, 9, 12, 18, 24, 30 and 36 stools These values along with those already arrived at for the correspondi dependently constructed sample series are given in Table I and repre

raphically in Fig. 1. It will be observed that, as observed by Holmes and 'Neal [1939], the two sets of values show an appreciable concordance.

Table I

elation between the standard deviations of the means for different constituent of sugarcane corresponding to sample units of different sizes (a) as determined independently for each sample series and (b) as calculated from the values for the lowest-sized sample series assuming complete randomness of variation within it

Variety and size of the sample	Juice per cent		Total solids per cent		Sucrose per cent		Glucose per cent	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
			Lyallpur (n=48)					
Co 318								
stool samples .	0·320	...	0·070	...	0·084	...	0·012	..
Do. .	0·240	0·226	0·046	0·050	0·054	0·059	0·008	0·009
Do. .	0·182	0·185	0·034	0·040	0·040	0·049	0·007	0·007
Do. .	0·189	0·160	0·034	0·035	0·040	0·042	0·006	0·006
Do. .	0·205	0·131	0·025	0·029	0·029	0·034	0·004	0·00
Do. .	0·110	0·113	0·024	0·025	0·027	0·030	0·004	0·004
Do. .	0·108	0·101	...	0·022	...	0·027	...	0·004
Do. .	0·100	0·092	...	0·020	...	0·024	...	0·003

Variety and size of the sample	Juice per cent		Total Solids per cent		Sucrose per cent	
	(a)	(b)	(a)	(b)	(a)	(b)
			Montgomery (n=16)			
Katha						
Stool samples	0·650	...	0·153	...	0·147	...
Do.	0·567	0·460	0·079	0·108	0·120	0·104
Do.	0·455	0·375	0·077	0·088	0·082	0·085
Do.	0·358	0·325	0·061	0·076	0·078	0·073
Co 285						
Stool samples	0·366	...	0·160	...	0·202	...
Do.	0·180	0·259	0·099	0·113	0·133	0·143
Do.	0·189	0·211	0·080	0·092	0·099	0·117
Do.	0·119	0·183	0·058	0·080	0·058	0·101
Co 312						
Stool samples	0·474	...	0·174	...	0·182	...
Do.	0·292	0·335	0·112	0·123	0·120	0·129
Do.	0·307	0·274	0·107	0·100	0·107	0·105
Do.	0·215	0·237	0·061	0·087	0·066	0·091

In the present study, therefore, we have worked out the standard
tions for ten stool samples by dividing the values of five-stool samples

As has already been stated, four varieties of sugarcane were a
on four different dates at Lyallpur, five varieties on three different d
Gurdaspur and three varieties on two different dates and also one o
different dates at Montgomery. At Rawalpindi, where, owing to the s
of winter, crushing of cane has to be finished before the onset of fro
three varieties under observation were analysed only once.

As mentioned already, ten replicated samples of five stools eac
obtained for the different varieties, the total area being about 1/16 acre
each variety with approximately 5 per cent samples on any one date of a
The chemical analysis included the determination of juice percentage
solids and sucrose. Glucose was not estimated because the relative a
of this constituent present in the juice is very small and further, as ha
shown in our previous paper, this figure being subject to the largest amo
error, any attempt to reduce it to the level of that for sucrose would be s
ful only if the sample size could be increased inordinately.

The analytical work carried out during the season 1936-37 at
places involved $43 \times 10 = 430$ analyses, and as the presentation of the a
cal data for so many samples of juice would have taken a large amo
space, these are not given and from the point of view of the problem in
the final figures of the coefficient of variation of the ten replicate samp
five stools each, determined separately for each variety and analysed
particular date, have been considered sufficient.

Another important point is that during the year 1936-37 we were
ducting a systematic sugarcane survey of some of the more important va
growing in the districts of Lyallpur and Montgomery and had reserv
this enquiry about 10 *marlas* of a standing crop of average canes o
variety at various centres in these districts. For the sake of conve
and also with the object of forming an idea of the limits of accuracy
collection and analysis of these sugarcane survey samples, work on the
ing of sugarcane was also carried out simultaneously on the same
Further, the sugarcane survey necessitated the withdrawal of larg
samples every fortnight. It was, therefore, anticipated that as a res
repeated sampling and consequent thinning of the crop reserved, the
in the replicate samples might be rather high. Some objection may be
against the amalgamation of these two enquiries but in view of the fa
in a ripening test, samples of cane have to be withdrawn periodically fr
same plots, it was thought that a study of the variations in the quality
crop at definite intervals might prove to be of considerable interest.

The figures of the coefficients of variation mentioned above hav
worked out for different constituents and the results presented in Ta
As will be seen, the data pertaining to any one variety analysed at di
stations have, for the sake of convenience in presentation, been asse
together. The coefficients of variation have been worked out for jui
other constituents, both when these latter are expressed as percenta
juice and on cane.

TABLE II

fficients of variation for different constituents of different varieties of sugar-cane grown at various stations and analysed on different dates

lculated from the data of the analyses of ten random samples of five stools each)
(1936-37)

iety	Station	Date of analysis	Constituents expressed on juice		Constituents expressed on cane		
			Total solids	Sucrose	Juice	Total solids	Sucrose
285	Lyallpur .	16-12-36	3·71	8·25	1·73	3·34	7·45
,	,,	27-1-37	2·00	5·50	3·71	4·03	6·83
,	,,	3-3-37	3·62	5·94	3·04	3·85	5·82
,	,,	9-4-37	3·90	6·09	3·89	4·48	6·37
		Mean .	3·31	6·45	3·09	3·92	6·62
,,	Gurdaspur	30-11-36	4·25	5·83	5·73	3·23	4·00
,,	,,	26-1-37	3·22	4·95	1·81	3·07	5·20
,,	,,	12-3-37	2·51	3·34	5·75	5·86	6·22
		Mean .	3·33	4·71	4·43	4·05	5·14
,,	Montgomery	9-11-36	2·68	3·98	1·95	1·49	2·63
,,	,,	28-1-37	3·18	4·29	1·35	3·30	4·11
		Mean .	2·93	4·13	1·65	2·40	3·37
,,	Rawalpindi	21-12-36	1·69	2·97	1·06	1·78	2·90
	Mean .		3·08	5·11	3·00	3·44	5·15
312	Lyallpur	16-12-36	5·85	8·96	1·44	6·34	9·85
,,	,,	27-1-37	5·79	10·97	2·60	6·23	10·91
,,	,,	3-3-37	4·76	6·11	3·16	7·59	8·28
,,	,,	9-4-37	4·34	6·18	2·24	5·52	6·82
		Mean .	5·19	8·05	2·36	6·42	8·96
,,	Gurdaspur	30-11-36	8·94	12·54	1·28	6·85	11·64
,,	,,	26-1-37	5·57	10·81	0·68	6·04	11·29
,,	,,	12-3-37	3·44	4·77	2·05	4·27	5·65
		Mean .	5·98	9·37	1·34	5·72	9·53
,,	Montgomery	9-11-36	2·59	4·43	1·63	3·26	5·01
,	,,	28-1-37	6·09	10·02	2·78	7·42	10·31
		Mean .	4·34	7·22	2·20	5·34	7·66
.	Rawalpindi	21-12-36	1·46	3·12	1·12	2·07	3·49
	Mean .		4·88	7·79	1·90	5·56	8·32

Variety	Station	Date of analysis	Constituents expressed on juice		Constituents expressed on cane		
			Total solids	Sucrose	Juice	Total solids	
Co 223	Lyallpur .	16-12-36	2·77	3·86	2·24	2·25	
,,	,,	27-1-37	3·18	5·50	2·04	3·21	
,,	,,	3-3-37	3·04	4·86	2·83	2·75	
,,	,,	9-4-37	4·06	5·98	3·56	5·78	
		Mean .	3·26	5·05	2·67	3·50	
,,	Montgomery	9-11-36	5·14	7·22	2·45	4·71	
,,	,,	28-1-37	1·81	3·67	1·58	2·01	
,,	,,	13-3-37	1·18	1·88	1·27	1·29	
		Mean .	2·71	4·26	1·76	2·61	
	Mean .		3·03	4·71	2·28	3·14	
Co 313	Lyallpur .	16-12-36	5·10	8·15	2·47	3·86	
,,	,,	27-1-37	2·96	2·75	2·93	3·46	
,,	,,	3-3-37	7·47	10·03	3·66	7·58	
,,	,,	9-4-37	3·95	8·20	1·53	3·90	
		Mean .	4·87	7·28	2·65	4·70	
Co 213	Gurdaspur	30-11-36	5·72	7·95	1·56	5·08	
,,	,,	26-1-37	3·55	5·65	1·13	3·48	
,,	,,	12-3-37	5·63	5·43	1·92	4·46	
		Mean .	4·97	6·34	1·54	4·34	
Co 300	Gurdaspur	30-11-36	5·83	8·04	1·75	5·56	
,,	,,	26-1-37	4·14	6·22	1·84	3·68	
,,	,,	12-3-37	4·12	5·47	2·71	4·09	
		Mean .	4·70	6·58	2·10	4·44	
Co 331	Gurdaspur	30-11-36	6·45	10·27	2·23	5·98	
,,	,,	26-1-37	3·03	5·63	2·31	4·94	
,,	,,	12-3-37	6·82	9·28	2·80	6·75	
		Mean .	5·43	8·39	2·45	5·89	
Co 290	Montgomery	9-11-36	3·62	6·70	2·02	4·42	
,,	,,	28-1-37	7·74	10·12	1·97	7·48	
		Mean .	5·68	8·41	2·00	5·95	
Katha	Rawalpindi	21-12-36	0·88	1·52	1·65	1·10	
Co 318*	Lyallpur .	25-3-36	1·60	2·58	2·72	..	

*In this case instead of five stools, six stools constituted the sampling unit

The data presented in this table throw considerable light on the co-ient of variations for different constituents of cane as well as on the varia-s due to different varieties of cane, the influence of different stations, atic and soil effects, and also the variations which occur at various stages ipening of the cane during the period of its growth.

The results of the analysis of sugarcane are usually expressed either ercentages on juice or on cane. Whatever the method of expression pted, the data presented in Table II show that the coefficient of variation lmost the same. This, however, is not in conformity with the findings ting to Co 285 and Katha reported in our previous paper. Those were d upon the data pertaining to only two varieties which were analysed e in the season. The conclusions now arrived at cover a much wider ge for any variety with regard both to the dates of analyses and the lities surveyed and for this reason may be regarded as more reliable.

The coefficients of variation as affected by the different factors mentioned ve will now be discussed separately under different heads.

fficients of variation of the different constituents of cane

Considering the mean values for the coefficients of variation for the e constituents, viz. juice, total solids and sucrose for all the varieties, ill be observed that, except in the case of Katha from Rawalpindi, this re is the lowest for juice and highest for sucrose. The variability for rose is invariably higher than that for total solids, being about one and a times the latter. This may be due to the fact that sucrose is more sensi-to changes in the environmental conditions than are total solids. It been observed, for example, that, as a result of the action of frost upon susceptible varieties of sugarcane, while total solids may not undergo great change, the fall in the amount of sucrose due to inversion is rela-ly more pronounced.

iations between different varieties

Considering the comparative figures of coefficients of variations of different eties, it will be noticed that, as regards juice, Co 285 showed the highest ation both at Lyallpur and at Gurdaspur, while Co 312 at Gurdaspur the lowest figure. As far as total solids are concerned, the highest e was obtained for Co 312 at Lyallpur. The values for this variety at laspur and Montgomery were also very high, being next only to Co 290 Iontgomery and Co 331 at Gurdaspur. Katha a local variety gave at alpindi the lowest coefficient of variation for total solids and was followed o 285 and Co 223 at Montgomery. As regards sucrose, the highest figures given by Co 312, Co 290 and Co 331 and lowest by Katha and Co 223, showing a high correlation between the variation in sucrose and that in solids.

ations due to localities

Since all the varieties were not available at different stations it is not ble to say precisely to what extent the meteorological and soil factors iar to different localities affect the extent of variation. However, the relating to Co 285 and Co 312, both of which were available at three

stations, viz. Lyallpur, Gurdaspur and Montgomery and Co 313 from Ly and Gurdaspur, supply a certain amount of information on the Considering the data for the two varieties collectively (Table II lowest figures for coefficients of variation both for juice and sucrose obtained at Montgomery. This is rather surprising, since most of th at this station is characterized by the presence of scattered patches cont a high concentration of salts, mostly those of sodium.

TABLE III

Coefficients of variation for the same varieties in different localities

	Lyallpur		Gurdaspur		Montgome	
	Juice	Sucrose	Juice	Sucrose	Juice	Suc
Co 285 . .	3·09	6·62	4·43	5·14	1·65	3
Co 312 . .	2·36	8·96	1·34	9·53	2·20	7
Mean . .	2·72	7·79	2·89	7·34	1·93	5
Co 313 . .	2·65	6·70	1·54	6·19	..	.
Co 223 . .	2·67	4·75	..	..	1·76	4

The corresponding figures from Lyallpur and Gurdaspur were almo same. When, however, we consider the figures for Co 313 which was ava both at Lyallpur and at Gurdaspur, we find that the coefficient of variati juice was about 60 per cent higher at Lyallpur than at Gurdaspur was also the case with Co 312. The figures for sucrose did not show an difference. Evidently the data at our disposal are insufficient to wa any general conclusions being drawn.

Variations in relation to the degree of maturity of the crop

Some workers believe that as the crop advances towards maturit different constituents in cane reach a more stable figure. Therefore, l the season, it may be possible to reduce the size of the sample withou appreciable sacrifice in accuracy. The data presented, however, do not support to such a view. In Table IV the figures for coefficient of vari of different varieties grown at various stations have been so re-arranged the figures derived from analyses carried out early in the season appe columns 1 and 2 and those relating to analyses done late in the seas columns 3 and 4. It will be seen that in a number of cases the varia is greater in the early season than in the late season, while in other quite the reverse is the case. The mean values for the two sets of vari given at the foot of the table do not differ appreciably from each other. is easily explained if we take into consideration the fact that sugarcan very heterogeneous crop, and in a field, canes of different ages are ava at any time during the season,

TABLE IV

Coefficients of variation for different varieties of sugarcane as determined by analysing them early and late in the season

		Analysed early in the season		Analysed late in the season	
		Juice	Sucrose	Juice	Sucrose
285	Lyallpur . . .	1·73	7·45	3·47	6·10
,,	Gurdaspur . . .	5·73	4·00	5·75	6·22
,,	Montgomery . . .	1·95	2·63	1·35	4·11
312	Lyallpur . . .	1·44	9·85	2·70	7·50
,,	Gurdaspur . . .	1·28	11·64	2·05	5·65
,,	Montgomery . . .	1·63	5·01	2·78	10·31
223	Lyallpur . . .	2·24	3·31	3·20	5·37
,,	Montgomery . . .	2·45	6·96	1·27	1·78
313	Lyallpur . . .	2·47	6·92	2·60	8·34
213	Gurdaspur . . .	1·56	7·27	1·92	5·70
300	Gurdaspur . . .	1·75	7·75	2·71	5·10
331	Gurdaspur . . .	2·23	9·40	2·80	8·48
290	Montgomery . . .	2·07	7·14	1·97	9·91
	Mean .	2·20	6·90	2·60	6·50

This point was further examined and more definite conclusions arrived from the data relating to varietal trials carried out at Gurdaspur, Karnal Montgomery during the season 1938-39. A number of varieties were lysed at these stations three times during the crushing season, viz. in ember 1938 and January and February 1939. The system of replica- n followed at Gurdaspur was six varieties (Co 312, Co 313, Co 385, Co 421, 285 and Co 371) in four blocks ; at Karnal there were six replications of varieties (Co 312, Co 385, Co 421, Co 285 and Co 395) and at Montgomery e replications of five varieties (Co 312, Co 421, Co 285, Co 395 and Co 371). size of the experimental plots at all the places was 1/40 of an acre and three pling units of 10 stools each were taken for analysis from each plot. above localities represent three important cane-growing tracts of the vince which have different climatic conditions.

The data pertaining to the three dates of analysis have been examined with reference to sucrose. The analyses of variance for each of the e dates have been worked out separately and are presented in Table V

TABLE V

Analysis of variance of the values for sucrose estimated on three different d

(Expressed as percentage on cane)

Station	Date of analysis	Source of variation	Degrees of freedom	Sum of squares	Mean square	Sampling error per sampling unit of 10 stools each	Mean value for sucrose	Co va
Gurdaspur .	December, 1938	Between plots	23	33·60	...			
		Within and between plots samples	48	6·32	0·132	±0·363	7·96	
Do. .	January 1939	Between plots	23	47·51	...			
		Within and between plots samples	48	12·31	0·256	±0·506	8·62	
Do. .	February, 1939	Between plots .	23	67·10	...			
		Within and between plots samples	48	11·37	0·237	±0·487	9·08	
Karnal .	December, 1938	Between plots	29	56·89	...			
		Within and between plots samples	60	7·11	0·118	±0·344	9·38	
Do .	January, 1939	Between Plots	29	77·76	...			
		Within and between plots samples	60	10·05	0·167	±0·411	10·29	
Do .	February, 1939	Between plots	29	68·51	...			
		Within and between plots samples	60	16·76	0·279	±0·528	10·70	
Mantgomery	December, 1938	Between plots.	14	38·04	...			
		Within and between plots samples	30	11·12	0·371	±0·609	9·10	
Do.	January, 1939	Between plots .	14	24·15	...			
		Within and between plots samples	30	9·16	0·305	±0·552	8·25	
Do. .	February, 1939	Between plots	14	39·36	...			
		Within and between plots samples	30	10·24	0·341	±0·584	9·42	

Considering the figures for sampling errors and the coefficients of v tion for the three different dates it will be observed that there is no consi difference between these three sets of figures at any of the stations. Be the extent of differences between the figures for the three dates of analy not very pronounced at any station. These results confirm the concl already arrived at and show definitely that in order to obtain the same d of accuracy in the figures of chemical analysis, one would not be justifi reducing the size of the sample when the canes are to be examined la season.

... and coefficients of variation for juice, total solids and sucrose (on cane) in different varieties for five and ten stools samples

Variety	Juice					Total solids					Sucrose				
	Per cent	Standard deviation		Coefficient of variation		Per cent	Standard deviation		Coefficient of variation		Per cent	Standard deviation		Coefficient of variation	
		5 stools	10 stools	5 stools	10 stools		5 stools	10 stools	5 stools	10 stools		5 stools	10 stools	5 stools	10 stools
Co 285 . .	63·3	1·90	1·34	3·00	2·12	11·10	0·38	0·27	3·44	2·43	8·99	0·46	0·33	5·15	3·64
Co 312 . .	65·7	1·25	0·88	1·90	1·34	10·40	0·58	0·41	5·56	3·93	8·30	0·69	0·49	8·32	5·88
Co 223 . .	65·7	1·50	1·06	2·28	1·61	11·51	0·36	0·25	3·14	2·22	9·69	0·44	0·31	4·51	3·19
Co 313 . .	64·1	1·70	1·20	2·65	1·87	12·49	0·59	0·42	4·70	3·32	10·48	0·70	0·50	6·70	4·74
Co 213 . .	67·3	1·04	0·74	1·54	1·09	10·60	0·46	0·33	4·34	3·07	8·53	0·53	0·37	6·19	4·38
Co 300 . .	65·8	1·38	0·98	2·10	1·48	10·41	0·46	0·33	4·44	3·14	8·58	0·53	0·37	6·22	4·40
Co 331 . .	64·9	1·59	1·12	2·45	1·73	10·01	0·59	0·42	5·89	4·16	7·76	0·66	0·47	8·45	5·98
Co 290 . .	68·7	1·37	0·97	2·00	1·41	10·20	0·61	0·43	5·95	4·21	7·94	0·68	0·48	8·52	6·03
Mean . .	65·7	1·47	1·04	2·24	1·58	10·84	0·50	0·36	4·68	3·31	8·79	0·59	0·42	6·76	4·78
Katha . .	60·4	1·00	0·71	1·65	1·17	11·63	0·13	0·09	1·10	0·78	9·52	0·22	0·16	2·30	1·63
Co 318 . .	62·5	1·66	1·29	2·66	2·06	12·49	0·20	0·15	1·60	1·24	9·60	0·24	0·19	2·50	1·94

Limits of accuracy for samples of different sizes

Most of the data discussed so far have been obtained from the ex tion of the results of five-stool samples and as such are not direct parable with those given in the first paper of the series. For example, paper it was mentioned that the figures for sucrose and total solids ex on juice were accurate within a range of about $\pm 0 \cdot 5$, for glucose $\pm 0 \cdot 10$ and for juice within $\pm 2 \cdot 5$. In order to have an idea of the of agreement between these figures and those obtained now, the ra variations, for the mean values of juice, total solids and sucrose ha worked out and are given in Table VI. The standard deviations o are based upon the mean figures of the coefficients of variation for d varieties given in last line at the end of each variety in Table II.

The values for ten-stool samples are calculated from those for fi samples by the application of the formula $\sigma_{-m} = \frac{\sigma}{\sqrt{n}}$. For the sake c parison the values for Co 318 obtained previously have been recal so that they may become comparable with those for the other variet obtained and are given in the last line of the table in the column for fi samples. As a matter of fact, however, these are for six-stool s In the first paper of the series the limits of accuracy obtained final given in terms which could be compared directly with those obtai Leather's method of representation [1913]. Therefore, to be strictly c able to those obtained previously, the figures for limits of accuracy for given in Table VI should first be expressed on juice and then doubled

Considering the figures for ten-stool samples, it will be observed the case of juice the range of accuracy for all the varieties with the ex of Co 285 is smaller than that obtained previously for Co 318. Even case of Co 285 it is only slightly wider. However, in the case of suc all the varieties, except Katha, it is considerably higher than that for The figures for Co 285, Co 223, Co 213, and Co 300 are almost double the remaining four varieties about two and a half times that of Co 31 the figures now obtained, based as these are on a more comprehensiv give a better estimate of the range of variation in accuracy for the v studied.

General conclusions

As has been mentioned already, the present investigation was ta with the object of determining how far the conclusions pertaining to th of Co 318 grown at Lyallpur during 1935-36, reported in part I of th were applicable to other varieties and also whether local conditions a sonal variations modified the results to any appreciable extent.

It has been found that, of the coefficient of variations for th constituents of cane, viz. juice, total solids and sucrose, the highest va been obtained for sucrose and lowest for juice. This holds for all the ties except Katha. Further, the range of variation in the values of efficient of variabilities is not the same for each variety. Differences and climatic conditions may also excercise some influence in modifyin

values. However, the data examined do not show any wide differences in the values of the coefficients of variation when the canes are analysed during different periods in the season. The range of variation for some of the varieties analysed late in the season is as great as in the early season. Even for the same variety the coefficient of variability both in the early and in the late season may differ with locality. For example, the variabilities of the value of sucrose for Co 312 at Gurdaspur were found to be 11·64 and 5·65 respectively for the percentage of sucrose determined early and late in the season. The same variety at Montgomery, however, showed a variability of 5·01 in the early season as against 10·31 in the late season. Averaging out the effects of varieties and localities, we find that, as far as juice and sucrose are concerned, the variabilities found in the early season are not appreciably different from those in the late season. Confirmation of this conclusion has been obtained from the data for sucrose from varietal trials in which each variety was examined thrice in the season. These results, therefore, do not lend support to the view, which on theoretical considerations may seem to be plausible, that when a sample of sugarcane is to be analysed late in the season, one can reduce its size without any loss in accuracy.

As regards the diminution of error with increase in the size of the sample, it has been found that with a ten-stool sample, the error for the percentage of juice becomes as low as was obtained with Co 318. For sucrose, however, the errors are about two to two-and-half times as great. If, as recommended already, a ten-stool single sample is to be employed for chemical analysis, the mean errors attaching to juice, total solids and sucrose expressed as percentages on cane at 5 per cent level of probability will be $\pm 2 \cdot 1$, $\pm 0 \cdot 72$ and $\pm 0 \cdot 84$ respectively. These figures are evidently higher than those mentioned in the previous paper of the series, but based as they are on the data from eight varieties, these offer a wider range of application. Data relating to replicated varietal trials and the conclusions reached therefrom will be presented and discussed in a later contribution.

Summary

The investigation reported in this paper was carried out in continuation of the work which has already been published as part I of the series.

Most of the data examined were obtained in connection with the sugarcane survey during the season 1936-37 and the results obtained were derived from and are applicable to the chemical analysis of sugarcane grown under Lyallpur conditions.

The values for the coefficients of variation for various constituents of cane discussed in this paper were arrived at from the figures for the lowest-sized sample by the use of the method which assumes a complete randomness of variation between the analytical values of different constituents in the case of the units comprising a five-stool sample. The values for the larger-sized samples thus calculated compare very favourably with those obtained from a random combination of original units. In dealing with the data from varietal trials, however, where a ten-stool sample was used, the coefficient of variation for sucrose was calculated directly.

The coefficients of variation of different constituents of sugarca whether expressed as percentages on juice or on cane are almost the sam This conclusion, which is based upon the examination of a large number cases and hence is more reliable, is at variance with that arrived at previous from a consideration of the data which related to only two varieties analys once in the season.

A high correlation has been found to exist between the coefficients variation for total solids and sucrose, the values for the former being invariab smaller than those for the latter.

Of the coefficients of variation for juice, total solids and sucrose, that f sucrose, in the case of all the varieties examined has been found to be t highest and for juice the lowest. The case of Katha, however, was an exceptio

The different varieties examined do not follow the same order with rega to the coefficients of variation of their three constituents, viz. juice, tot solids and sucrose.

The coefficient of variation associated with any definite size of the samp does not decrease with advance in season. Therefore, to obtain the sa degree of accuracy late in the season, the size of the sample for chemic analysis cannot be reduced below that which is required early in the seaso

The mean errors attaching to the estimation of juice, total solids a sucrose expressed on cane from a ten-stool sample have been found at t 5 per cent level of probability to be $\pm 2 \cdot 1$, $\pm 0 \cdot 72$ and $\pm 0 \cdot 84$ respective for the above constituents. These figures are evidently different from tho for Co 318 mentioned in the previous paper but based as they are on the da from eight different varieties these offer a wider range of application.

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A DISEASE OF PIGEON-PEA [*CAJANUS CAJAN* (L.) MILLSP.] CAUSED BY *DIPLODIA CAJANI* SPEC. NOV.

BY

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(With Plate XXXII and four text-figures)

DISEASED pigeon-pea [*Cajanus cajan* (L.) Millsp.] plants were received from the Botanical Sub-station, Imperial Agricultural Research Institute, Pusa, in November, 1939. On examination, the collar regions were found to be cankered. The cankers were of considerable size and deep seated, and were found to girdle the stem, leading ultimately to a collapse and death of the affected plants. The disease appeared to be different from those so far described on this crop from India.

Nowell [1923] reported three diseases of pigeon-pea in the West Indies, which infect roots, collar or lower stem. He stated that stem and collar-canker were observed in material from Carriacou and also referred to the existence of a serious stem-canker in Porto Rico, as recorded by Stevenson [1926].

Leach and Wright [1930] worked on the collar and stem-canker of (*Cajanus indicus*) pigeon-pea in Trinidad.

Recently Dastur [1939] reported that in the Central Provinces in 1938 well-grown cotton plants began to die off in large numbers. The stems were found to be broken a little above the ground level, and the owner of the crop attributed the death of the plants to a breaking of their backs. Dastur observed this breaking of the stem on *Phaseolus mungo* and *Cajanus indicus* to be accompanied by similar symptoms.

The work now presented was undertaken to determine the cause of the disease.

Symptoms of the disease

The primary symptoms of the disease as studied from artificially infected plants are thickenings and distortions at the collar region. After 20 to 30 days, elliptical lesions of various sizes, with dark edges, are formed at the region of distortion. Later on, they are transformed into large, deep-seated cankers (Plate XXXII, fig. 1, *b*). In a few cases the diseased plants recover partially by the formation of callus but generally the cankers are found to spread and girdle the stem with the result that the plant collapses.

Very often the stem at the cankered portion presents a twisted appearance due to an unequal development of the wood. In advanced stages of the disease the internal tissues of the stem, a few inches above the canker, are also discoloured. No discoloration takes place in the root-system.

Adventitious roots develop just above the region of the canker (Plat XXXII, fig. 1, *b*).

When examined microscopically the infected tissue of the pigeon-pe s found to be slate-blue in colour as described by Leach and Wright [1930] The mycelium is found to be present in the primary and secondary xyle vessels but there is no starch in the diseased tissues.

Isolation of the fungus

Diseased pigeon-pea plants were obtained from Pusa in 1939. Fro five of these the cankered portions were separated. After surface-steriliz tion small bits of the infected tissue were immersed in one per cent silv nitrate for a minute, followed by dipping in one per cent sodium chlorid These pieces were then placed on potato-dextrose-agar in tubes. In abou five to seven days fungal growth was observed on tissues taken from fou out of the five plants. All the cultures appeared to be morphologicall similar. On the tenth day pycnidia appeared in one culture and withi another 15 days in all the others also. Single-spore cultures were starte by the dilution plate method.

A similar disease again appeared on the pigeon-pea at Pusa in 194 The fungus was isolated and appeared to be similar to the one obtained i the previous year. It was grown on potato-dextrose-agar. The isolat from the four diseased plants of 1939 crop were labelled A, C, D and E, a the one from the 1940 crop as D-47.

Determination of pathogenicity of the fungus

For inoculation experiments, seeds of pigeon-pea (IP5) were first ste lized by dipping in formalin solution (1 : 320) for a minute and then dri by spreading them evenly on a sterilized petri-dish, kept covered with piece of muslin for two hours. These seeds were sown in sterilized soil.

Pigeon-pea plants of different ages were inoculated separately with pure culture of isolates A, C, D and E. The collar region of every seedli was cleaned with alcohol and then a piece of inoculum, removed from t edge of the plate culture, was placed upon it after or without woundi A swab of damp and sterilized cotton-wool was then placed over e ery i oculated spot and wrapped with another thin piece of the same.

After inoculation every plant was covered with a glass case, the interi of which had been sprayed with water. All inoculated plants were kept the pot-culture house for three days in order to protect them from outsi injuries. The cotton-wool wrappers were removed from the collars aft two weeks.

In all, four inoculation experiments were carried out with a view ascertaining if the cultures were capable of producing the disease. T details of these experiments are set out in tabular form.

As culture No. D-47 was obtained as late as January, 1941 (from t pigeon-pea crop sown in 1940), it was not possible to make any inoculati with this isolate at the time of the first experiment.

In the following tables the sign ++++ represents typical sympto associated with a very virulent attack by the pathogen ; +++ typi symptoms with a fairly strong attack ; ++ typical symptoms with a m

FIG. 1. (*a*) *Cajanus cajan* plant used as uninoculated control
(*b*) *C. cajan* plant inoculated with *Diplodia cajani* Ray Chaudhuri

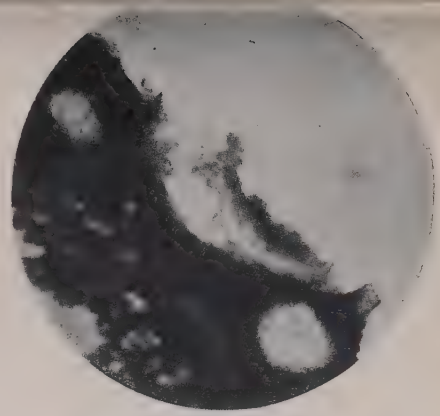


FIG. 2. Simple, globose pycnidia of *Diplodia cajani* Ray Chaudhuri (× 84)

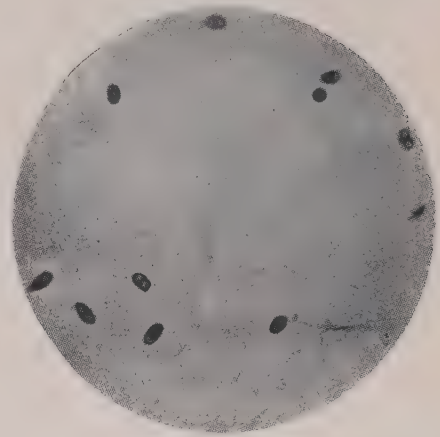


FIG. 3. Conidia of *Diplodia cajani* Ray Chaudhuri (× 150)

tack ; + a little distortion and swelling at the collar region ; and — absence infection.

Table I shows the results of the first experiment with seedlings $2\frac{1}{2}$—3 . high.

TABLE I

Inoculation of pigeon-peas with the fungus isolated from cankered plants

(Inoculated on 30 January 1940 ; experiment discontinued after 30 July 1940)

Inoculum from isolate	Number of seedlings inoculated	Treatment		Type of infection		Death due to canker	
		After wounding	Without wounding	Wounded	Un-wounded	Wounded	Un-wounded
. . . . .	10	5	5	+++	++	3	1
. . . . .	10	5	5	++++	+++	5	4
. . . . .	10	5	5	++++	+	0	0
. . . . .	10	5	5	+	+	0	0
trol	8	4	4	—	—	0	0

The plants in the first experiment were under observation for 181 days er which the experiment was discontinued. From the results given is ble I it is evident that isolate C was the most virulent in so far as all the nts inoculated with this isolate exhibited typical symptoms of canker ; plants inoculated after wounding, and all but one not wounded died. e isolate A was fairly virulent pathogen, producing typical symptoms all the inoculated plants and four out of ten died. Those inoculated with late D after wounding exhibited typical symptoms of the disease but y little swelling and distortion were observed in plants which were in- lated without wounding. None of the plants inoculated with this isolate d. Isolate E proved to be a weak pathogen and only a little distortion l swelling were produced at the collar. All the control plants were free n canker, and only one plant showed a small lesion on the wounded part, haps due to the healing effect.

In the second experiment two isolates, viz. C. and E were chosen to culate the seedlings $2\frac{1}{2}$—3 in. high. The results are shown in ble II.

TABLE II

Inoculation of pigeon-peas with the isolates C and E

(Inoculated on 27 April 1940 ; experiment discontinued after 9 August 1940)

oculum from isolate	Number of seedlings inoculated	Treatment		Type of infection		Death due to canker	
		After wounding	Without wounding	Wounded	Un-wounded	Wounded	Un-wounded
. . . . .	40	20	20	++++	++	15	6
. . . . .	40	20	20	+	+	0	0
rol	40	20	20	—	—	0	0

The plants in the second experiment were under observation for 1 days, after which the experiment was discontinued. This experiment al proved that the isolate C was a very strong pathogen. The plants inoc lated with this isolate exhibited typical symptoms of the disease. Sevent five per cent of the plants inoculated after wounding died, and 30 p cent of those inoculated without wounding collapsed—altogether plants out of 40 died due to the disease. Plants inoculated with isolate showed a little swelling and distortion at the collar region, but none die The control plants remained quite healthy and normal.

In the third experiment, 184 plants of two different ages were inoculate The isolates used for inoculation were A and C. The results are given Table III.

TABLE III

Inoculation of pigeon-peas with isolates A and C

(Inoculated on 23 August 1940 ; experiment discontinued after 3 December 1940)

Inoculum from isolates	Height of the seedlings (inches)	Age of seedlings (days)	Number of seedlings inoculated	Treatment		Type of infection		Death due to cank	
				After wounding	Without wounding	Wounded	Unwounded	Wounded	Unwound
A . .	2½—3	9—10	40	20	20	+++	++	2	0
C . .	2½—3	10	40	20	20	+++	++	0	0
Control .	2½—3	9—11	40	20	20	—	—	0	0
A . .	5—6	21—22	22	11	11	+++	++	2	0
C . .	4—6	20—21	23	12	11	+++	++	0	0
Control .	5—6	20—22	19	10	9	—	—	0	0

The plants in the third experiment were under observation for 117 da after which the experiment was discontinued. From Table III it is evid that the age of the plant makes practically no difference as far as the pat genic activity of the fungus is concerned. Isolates A and C produced typ symptoms of the disease irrespective of the age of the host. As bef control plants were quite healthy and normal. Only a few plants died to canker within the period of 117 days, possibly due to impaired acti on the part of the parasite owing to unfavourable weather conditions du the period of 23 August 1940 to 3 December 1940.

In the fourth experiment all the five isolates including D-47 (from dise pigeon-pea plant of the 1940 crop) were used for inoculations. A large nun of plants were inoculated with D-47 since this particular isolate was used in the previous experiments. Results of the fourth experiment seedlings 2½—3 inches high are given in Table IV.

TABLE IV

Inoculation of pigeon-peas with isolates A, C, D, E and D-47

(Inoculated on 16 April 1941 ; experiment discontinued on 5 August 1941)

Inoculum from isolate	Number of seedlings inoculated	Treatment		Type of infection		Death due to canker	
		After wounding	Without wounding	Wounded	Un-wounded	Wounded	Un-wounded
A	20	10	10	+++	++	6	1
C	20	10	10	+++	++	9	3
D	20	10	10	++	+	3	0
E	20	10	10	+	+	1	0
D-47	80	40	40	++++	++	36	22
Control	20	10	10	—	—	0	0

Table IV shows that isolate C and D-47 are very virulent.

It appears from the above experiments that plants which were inoculated after wounding suffered more from the disease than those which were inoculated without wounding, and that an injury at the collar region favours the development of the fungus as well as its pathogenic activity on the host.

The cankers produced in plants as a result of inoculations were identical with those occurring in nature and the discoloration of the internal tissues in the stem extended to a considerable distance. The fungus was also re-isolated from the cankers.

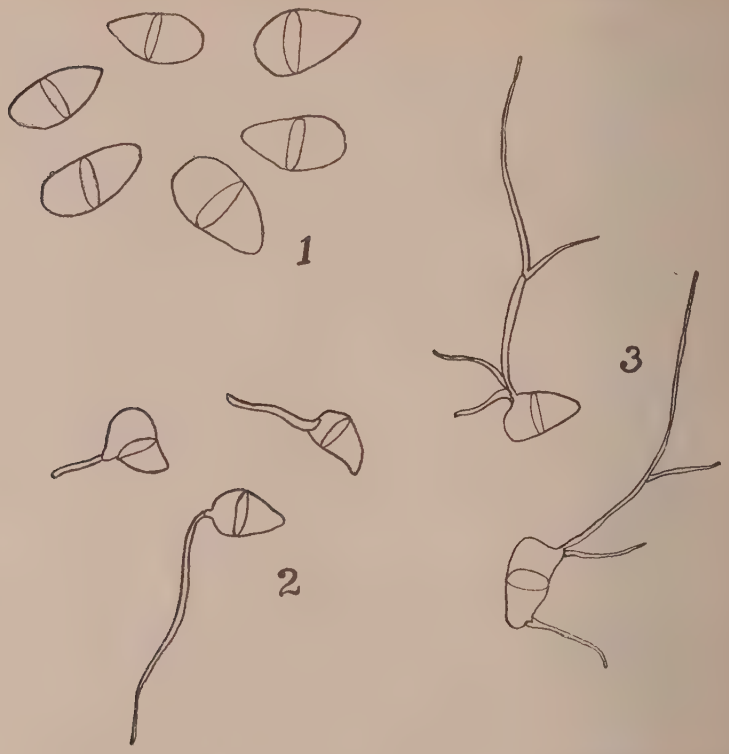
CHARACTERS OF THE PATHOGEN

The mycelium is septate, at first hyaline, but gradually becomes olive-green to brown, and ultimately, in mass, it appears black ; its average width is 4·3μ with a range of 2·6μ to 8·6μ. There is abundant aerial mycelium.

The pycnidia are simple, globose (Plate XXXII, fig. 2), osteolate, immersed at first, later bursting through the epidermis, glabrous ; the average diameter is 405μ with a range of 301-464μ.

Conidia are borne on short needle-shaped conidiophores, at first hyaline, later turning from light to dark-brown ; two-celled (Plate XXXII, fig. 3), mostly egg-shaped, sometimes ovoid to ellipsoid (Fig. 1), attached to the conidiophores with the narrower end ; their average size is 25·1 × 12·7μ with a range of 21·5—30·1 × 10·8—12·9μ.

The upper cell of the conidium invariably germinates first. When a hanging drop culture was examined under the microscope it was found that the germ-tube is produced by the upper cell in about five hours (Fig. 2). The lower cell germinates after 15 to 20 hours in most cases. The germ-tube branches at the base, and sometimes the germ-tube produced by the upper cell branches considerably before that arising from the lower cell (Fig. 3).



FIGS. 1-3. *Diplodia cajani* n. sp. (1) conidia, × 550 ; (2) Germination of conidia, × 430
(3) Same, later stage, × 430

Temperature relations. The isolates A, C, D, E and D-47 were grow on plates of potato-dextrose-agar and their temperature curves are shown Fig. 4.

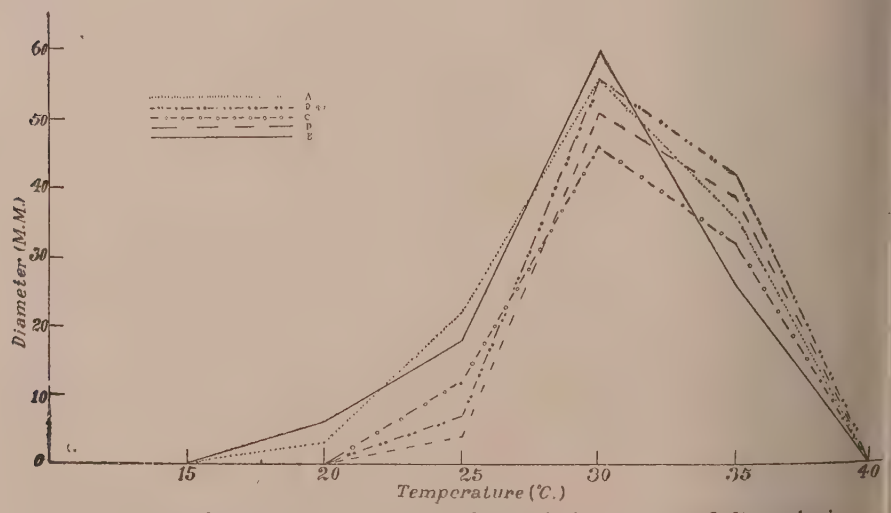


FIG. 4. Growth temperature curves of five isolates of *Diplodia cajani* n. showing diameters of colonies after two weeks

The experiment was discontinued after two weeks. No growth was observed in any of the isolates at a temperature of 15°C. and below. A and E showed marked growth at 20°C. to 25°C., the respective diameters of the colonies being 3 mm. and 6 mm. at 20°C. and 22 mm. and 18 mm. at 25°C. Isolates C, D, and D-47 grew at 25°C. to 30°C. and their growth was found to be 12 mm., 4 mm. and 7 mm. at 25°C. and 46 mm., 51 mm. and 56 mm. at 30°C. respectively. In all cases maximum growth was found to take place at 30°C. and the growth of the isolate E was found to be 60 mm.

Above 30°C. the growth fell off rapidly with increasing temperature, so that the growth of A, C, D, E and D-47 at 35°C. was found to be 36 mm., 2 mm., 39 mm., 26 mm. and 42 mm. repsectively and no growth was observed at 40°C.

An experiment was performed with a view to find out the influence of temperature on sporulation of each of the isolates when grown on different media.* The fungus was grown on plain agar (two per cent), potato-dextrose-agar, oatmeal agar, Dox's agar and Brown's Standard Synthetic agar at six different temperatures, viz. 10°C., 15°C., 20°C., 25°C., 30°C. and 35°C. and the experiment was under observation for 76 days, after which it was discontinued.

All the isolates showed very poor growth and fruiting bodies were not formed on plain agar at 10°C., 15°C., 20°C., 25°C., 30°C. and 35°C. while most luxuriant growth accompanied by the best formation of pycnidia was observed on potato-dextrose-agar at all the temperatures mentioned above. Fair growth was observed on oatmeal agar at 10°C., while at higher temperatures the growth was very luxuriant. Pycnidia were produced only in one tube at 10°C. whereas at 20°C. and 25°C. pycnidia were developed in all the cultures on this medium. On Dox's agar luxuriant growth was not observed in all the cultures at 10°C. but at higher temperatures all the isolates showed vigorous growth, while pycnidia were regularly produced at 15°C., 20°C. (except in isolate E) and 25°C. On Brown's Standard Synthetic agar, growth appeared to be rather poor at 10°C. fair growth at 15°C. and 35°C. full luxuriant at 20°C., 25°C. and 30°C. Pycnidia were regularly developed only at 20°C. (except in the culture containing isolate C), and they were completely absent in all the cultures at 10°C., 25°C. and 35°C.

* The following are the compositions of the media employed in the experiment, the quantities given being the amounts in one litre of the solution :—

(1) Plain agar . . . . Agar 20 gm.

(2) Potato-dextrose-agar . . Potato 200 gm., dextrose 20 gm., agar 20 gm.

(3) Oatmeal agar . . . Oatmeal 30 gm., agar 20 gm.

(4) Dox's agar . . . . Magnesium sulphate 0·5 gm., potassium phosphate 1·0 gm., potassium chloride 0·5 gm., ferrous sulphate 0·01 gm. (trace), sodium nitrate 2 gm., cane sugar 30 gm., bacto agar 15 gm.

(5) Brown's Standard Synthetic agar . . . . . Glucose 2·0 gm., asparagin 2·0 gm., $MgSO_4$ 0·75 gm., K_3PO_4 1·24 gm., agar 15 gm.

Another experiment was performed with a view to determining the eff of different temperatures on pycnidial development on sterilized host tissu The inoculated host tissues were subjected to three different temperatu viz. 10°C., 20°C. and 30°C. and the experiment was under observation 78 days, after which it was discontinued.

At 10°C. A and C exhibited very poor growth, D and E grew fairly w while D-47 did not grow at all; pycnidia were produced only by D and E this temperature.

At 20°C. luxuriant growth was observed in the case of A, D, E and D- while C exhibited fair growth. Pycnidia were produced in all the cultures this temperature.

At 30°C. all the cultures exhibited luxuriant growth accompanied regular development of pycnidia.

Discussion

The fungus isolated from cankered pigeon-peas is a typical *Diplo* capable of causing the disease under reference. Apart from the report un-named species of *Diplodia* found by Leach and Wright [1930], the o other record of this genus on *Cajanus cajan* known to the author is that *Diplodia cacaoicola* P. Henn. by Stevenson [1926]. The origin of this rec is not known to the author, but it appears to be based on a conception of t species wide enough to include *Lasiodiplodia*, *Botryodiplodia* and *Chaet plodia*. Griffin and Moublanc had previously considered *D. cacaoicola* be a *Lasiodiplodia*, which they called *L. Theobromae* (Syn., *Botryodiplo Theobromae* Pat., *Macrophoma vestita* Prill. et Del., *Diplodia cacaoi* P. Henn., and *Lasiodiplodia nigra* App. et Lambert). This inversion genera is a clear indication of our poor understanding of morpholog criteria in *Diplodia* and its related genera, and forces one back to the wid accepted practice of naming species on a basis of host relationship, cou where possible with morphological criteria. It seems that the identity the fungus on *Cajanus cajan* recorded by Stevenson was not based on experimental study of the pathogen of the type of *Diplodia cacaoicola*, on morphological criteria only.

Diplodia dalbergiae Died. was described by Sydow and Butler [1916] *Dalbergia sisso* from Pulliyanur, Travancore, India. This member of the Le minosae belongs to a tribe adjacent to that to which *Cajanus cajan* belo but apart from pathogenic considerations, the *Cajanus* fungus also dif from *Diplodia dalbergiae* also in having simple and not chambered pycni

On the basis of a study of its pathogenicity and morphological charact it is proposed to create a new speices for the *Diplodia* causing canker *Cajanus cajan*, and to name it *Diplodia cajani*.

Diplodia cajani spec. nov.

Pycnidia simple, globose, at first immersed, later erumpent, ostiol 405 (301-464)μ ; conidiophores needle-shaped ; conidia at first contin and hyaline, later one-septate and dark, upper cell rounded, lower cell ta ing, 25·1 × 12·7 (21·5-30·1 × 10·8-12·9)μ.

Habitat. In living and dead stems of *Cajanus cajan* (L.) Millsp., P Bihar (October, 1939). Type in Herb. Crypt. Ind. Orient.; cultures in T Culture Collection, Imperial Agricultural Research Institute, New Delhi

tin diagnosis

Pycnidiis uniloculatis, globosis, primo immersis, deinde erumpentibus, iolatis, 405 (301-464)μ ; conidiophoris acicularibus ; sporulis primo conti- is hyalinisque, deinde uniseptatis suscisque, cellula superiore rotundata, eriore acuta, 25·1×12.7 (21·5-30·1×10·8-12·9)μ.

Habitat. In ramis vivis et emortuis *Cajani cajan* (L.) Millsp., Pusa, har (October, 1939). Typus in Herb. Crypt. Ind. Orient.; cultura in llectione Culturarum Typicarum, Imperial Agricultural Research Institute, w Delhi.

Nowell [1913] reported stem and collar-canker of pigeon-pea. He und an ascomycete to be uniformly present in the diseased material. The ngus consisted of dark hyphae which gave a slaty appearance to the wood ; black stroma was produced throughout the bark with long naked perithecia ich were produced in dense clusters and more or less united at the base. hite tendrils of unicellular spores were ejected both from these and from acent pycnidia, the former being coffin-shaped, the latter oval or oblong. e perfect stage of the fungus was never obtained during the present study. Nowell reported that infection experiments were carried out in dry weather, d the results obtained were negative but in the present work all the four culation experiments proved to be successful and the pathogenicity of the ngus has been definitely established.

Leach and Wright [1930] isolated the following fungi from the cankered eon-pea plants :—

(1) An Ascomycete with two pycnidial stages of *Phoma* and *Macrophoma* types
(2) A *Cephalosporium*
(3) Two species of *Fusarium*
(4) Two species of *Diplodia*
(5) *Myxosporium*

They found that the Ascomycete and one species of *Diplodia* were capable producing infection. They inoculated pigeon-pea plants with the Asycete and a species of *Diplodia* and both were found to be capable of ducing the infection. They inoculated pigeon-pea plants with the Asycete and *Diplodia* sp. at the stem, branch and collar regions, and found the attack was most virulent at the collar region. The Ascomycete was able of producing the infection in all the three regions, whereas the *Diplodia* produced infection only at the collar region. It is very surprising to note that although the *Diplodia* sp. was more virulent at the collar region than Ascomycete, and the number of plants cankered were more in the case of se inoculated with *Diplodia* sp. at the collar region, they write, the causal asite of the disease, therefore, is an Ascomycete and it seems to be most ulent at the collar region. They state that the Ascomycete is a member the genus *Physalospora*.

Dastur [1939], while working on the 'stem breaking' of cotton, isolated *arium* spp., *Rhizoctonia bataticola* and *Colletotrichum* sp. from the broken s of the stem. He found these fungi to be confined only to the dead ues, and no hyphae were found in the living tissues. The bending and

breaking of the stem was considered to be due to high winds. He observe a similar disease on pigeon-peas. It is clear that the disease is distinct fro the type of injury described by Dastur.

The four inoculation experiments definitely proved that although th fungus was capable of producing infection on the unwounded plants, a injury, in all the cases, enhanced the pathogenic activity of the fungus to great extent.

While studying the cultural characteristics of the new fungus *Diplod cajani* on various media, it was found that potato-dextrose-agar, oatmea agar, Dox's agar, Brown's Standard Synthetic agar and sterilized host tissu produced pycnidia in great abundance. The fungus, however, exhibite very poor growth on plain agar (two per cent) with the result that pycnidi were not produced.

Temperature relations of *Diplodia cajani* were determined by growin the fungus on plates of potato-dextrose-agar for a period of two weeks. A 30°C. the colonies reached maximum diameter, and this was found to b 60 mm. in the case of isolate E (Fig. 4). Next in order were A and D-4 which exhibited the colonies of same diameter measuring 56 mm.; while th colonies reached a diameter of 51 mm. and 46 mm. in the case of D and C respectively.

The growth fell off rapidly with increase of temperature, and at 35°C the colonies showed a diameter of 26 mm., 36 mm., 42 mm., 39 mm., an 32 mm. in the case of E, A, D-47, D and C respectively, and the growth wa altogether stopped at 40°C.

Below 30°C. the growth decreased rapidly with a decrease in tempera ture, and at 25°C. only 18 mm., 22 mm., 7 mm., 4 mm. and 12 mm. occurre in the case of E, A, D-47, D and C respectively. The growth of D-47, D an C stopped at a temperature of 20°C. while the isolates E and A showed n growth at 15°C.

Hence, it appears that the optimum temperature for the growth of th organism on potato-dextrose-agar was about 30°C. while the minimum an maximum lie somewhere below 20°C. and above 35°C. respectively.

Further, it was observed that of the various media tested potato-dex trose-agar appeared to be most suitable for the fungus, since very luxurian growth accompanied by the production of pycnidia was found on this mediu in all the temperatures ranging from 10°C. to 35°C. It was also found tha the optimum temperature for the sporulation of the organism on the variou media was 20°C.

The fungus was also grown on sterilized host tissues, and it was foun that all the isolates grew vigorously and produced pycnidia in abundanc at 20°C. and 30°C.

Leach and Wright [1930] stated that cankers, though they may be forme on apparently sound tissue, arise most commonly at points of injury cause by hoeing operations, breakages, and insects. Hence, they suggested tha injuries at the collar regions caused during cultural operations and careles hoeing should always be avoided. The disease assumes its most seriou aspect in this region, and care should be taken during hoeing operation During the course of inoculation experiments it was found that the pigeon pea plants which were injured at the collar region suffered the most virulen

attack of the pathogen, and hence it appears that damage due to the disease could be minimized to a great extent if necessary precautions are taken to avoid injuries at the collar region.

Summary

Thickening and distortion at the collar region are the primary symptoms of the canker disease of pigeon-pea (*Cajanus cajan*). Later on lesions are formed at this region which are ultimately transformed into large deep-seated cankers. Very often adventitious roots develop in the neighbourhood of the cankered region.

Diseased pigeon-pea plants of the 1939 and 1940 crops were obtained from Pusa. The fungus isolated was in all cases a species of *Diplodia*.

Healthy pigeon-pea plants of different ages were inoculated with pure cultures of *Diplodia* at the collar region after wounding and without it. Several isolates produced typical canker and caused death of the inoculated plants.

The fungus was grown on plates of potato-dextrose-agar for a period of two weeks and the temperature relations were determined. No growth was observed at 15°C. or below it, and maximum growth took place at 30°C. above which it fell off rapidly with increasing temperature, and no growth was observed at 40°C.

It was found that potato-dextrose-agar was the most suitable medium for growth and sporulation of the fungus at all temperatures between 10°C. and 35°C. After a period of 76 days it was found that 20°C. was the optimum temperature for the sporulation of the fungus on the various media tested.

The fungus was also grown on sterilized host tissue at different temperatures, and after a period of 78 days it was found that 20°C. to 30°C. was the optimum temperature for growth and sporulation of the fungus.

Since the characteristics of this fungus did not agree with any known species of *Diplodia*, a new species has been created and named *Diplodia cajani*.

It was found that the attack of the pathogen was very virulent when the collar region was wounded before inoculation; hence it appears that damage due to the disease can be minimized to a great extent if injuries to the collar regions are avoided.

Acknowledgements

I wish to express my gratitude to Dr G. Watts Padwick, Imperial Mycologist, Imperial Agricultural Research Institute, New Delhi, who kindly suggested the problem and gave me the benefit of valuable guidance throughout the progress of these investigations. He also took a good deal of interest in the diagnosis of the fungus, and read through the manuscript. I am thankful to Dr B. B. Mundkur for some helpful suggestions. My thanks are also due to Mr Azmatullah Khan who helped me in various ways.

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UTILIZATION OF WASTE PRODUCTS OF THE SUGAR INDUSTRY IN THE CANE FIELDS

II. PREPARATION OF COMPOSTS BY HOT FERMENTATION

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IN Part I [Srivastava, Chaturvedi and Rao, 1940], attention was drawn to the large quantities of press-mud, cane trash and bagasse available in sugar factories which are not being utilized at present. Experiments were therefore, started to determine the best method of composting these materials with a view to using them in the cane fields. Composts were prepared by the usual methods developed at Indore, i.e. by aerobic fermentation and also by act ated compost process as recommended by Fowler. The resulting manure was qauite satisfactory, but the process employed was too costly since periodical turning had to be given which required a lot of labour. There was also ernsiderable loss of nitrogen varying from 20 to 50 per cent and of dry matter from 40 to 60 per cent depending on the initial composition of the head. Though these losses were not abnormal when the nature of the process was taken into consideration, it was very desirable to reduce these, if possible.

Acharya and co-workers [1939] have claimed very good results for methods of composting by what they term hot fermentation, so far as conservation of nitrogen and dry matter is concerned. By this method, the material is su bjected first for a short period to aerobic and then to anaerobic fermentation until the compost is ready. Experiments have now been carried out on the composting of the waste products of the sugar factory by hot fermentation and the results have been very encouraging.

Experimental

Method of composting. For the preparation of the heaps, air-dried press-mud (moisture per cent 5·8), cane trash cut into lengths of two to three inches (moisture per cent 7·0) and air-dried bagasse (moisture per cent 4·2) were mixed in suitable proportions and well turned with a thin slurry of cowdung and molasses. The proportions used were such that nitrogen per cent of the heap was in the neighbourhood of 1·0 and C : N ratio, 30 : 1, for which purpose a 3 : 1 ratio of press-mud to bagasse or cane trash was most satisfactory. On the weight of the heap which was 600 lb., molasses and cowdung used were 2 per cent each (except in experiments 1A and 1B when the quantity was 3·3 per cent).

No turning was given to any heap, but care was taken to see that the aps remained moist by sprinkling water whenever necessary. Composts re taken to be ready when the heaps had developed a crumbled powdery ucture and a greyish-black appearance.

Group I. Experiments 1—3. The heaps were placed in trenches 6 ft. 4 ft. × 3 ft. loosely packed so that aerobic fermentation could proceed. ter exposure for seven to eight days, the heaps were covered with mud paste is stopping aeration. Only anaerobic fermentation was then possible and s continued until the composts were ready.

Group II. Experiments 4—6. The heaps were placed in trenches and ojected to aerobic fermentation for about a week as in the previous case. e heaps were fairly closely packed later so that fermentation was prac- ally anaerobic.

Group III. Experiments 7—9. Heaps were prepared on the ground l not in trenches. Otherwise, the procedure was the same as in group I.

Group IV. Experiments 10—12. Heaps were prepared on the ground l the procedure was as in group II.

Only sulphitation press-mud was used in all these experiments. Press-mud carbonatation factories contains only 7 per cent organic matter expressed C and 0·6 per cent N on a dry basis. Attempts were made to prepare com- ts from this material also by aerobic fermentation, but these did not ve satisfactory on account of the large amount of inorganic matter present. small percentage of nitrogen—it is less than half that in sulphitation ss-mud—precludes the addition of large quantities of organic matter in er to make up the deficiency.

TABLE I

Experiment	Composition of the heap					Time of composting	Per cent loss of dry matter	N per cent in the compost (on dry basis)	Per cent loss of nitrogen
	Press-mud	Cane trash	Bagasse	C : N ratio	N per cent				
						Months			
A	3	1	...	34 : 1	1·08	12·5	24·1	1·22	14·1
B	3	1	...	34 : 1	1·08	12·5	12·6*	1·08	12·5
A	6	1	1	36 : 1	1·07	8·2	18·6	1·19	9·1
B	6	1	1	36 : 1	1·07	9·0	20·0	1·21	9·3
A	3	...	1	38 : 1	1·05	7·5	21·3	1·21	9·6
B	3	...	1	38 : 1	1·05	7·5	13·0*	1·09	9·8
A	3	1	...	34 : 1	1·08	6·2	30·3	1·27	18·4
B	3	1	...	34 : 1	1·08	6·2	30·6	1·29	17·3
A	6	1	1	36 : 1	1·07	7·1	24·6	1·17	17·3
B	6	1	1	36 : 1	1·07	7·1	27·2	1·22	16·9
A	3	...	1	38 : 1	1·05	7·3	25·7	1·17	17·4
B	3	...	1	38 : 1	1·05	7·3	26·2	1·16	18·6
A	3	1	...	34 : 1	1·08	7·1	5·5*	1·01	11·9
B	3	1	...	34 : 1	1·08	7·1	12·9*	1·08	13·2
A	6	1	1	36 : 1	1·07	7·7	13·2*	1·05	14·6
B	6	1	1	36 : 1	1·07	7·7	5·7*	0·98	14·1
A	3	...	1	38 : 1	1·05	7·7	17·9	1·07	16·4
B	3	...	1	38 : 1	1·05	7·5	17·1	1·09	14·8
A	3	1	...	34 : 1	1·08	6·8	28·3	1·14	24·5
B	3	1	...	34 : 1	1·08	7·2	30·0	1·14	26·3
A	6	1	1	36 : 1	1·07	7·5	32·1	1·25	20·5
B	6	1	1	36 : 1	1·07	7·7	29·3	1·13	25·0
A	3	...	1	38 : 1	1·05	7·6	34·0	1·28	20·0
B	3	...	1	38 : 1	1·05	7·5	29·3	1·16	22·1

*The heaps marked, got mixed with the mud paste, so that the per cent loss of dry matter is less than in heaps, but this does not affect the results in the last column.

Results

From the results recorded in Table I, it can be readily seen that i these experiments, loss of nitrogen and dry matter is much less than in t where composting is done only by aerobic fermentation. The average n gen content of the composts is also fairly satisfactory, being about 1·2 cent. The period of composting is longer, but this is of no consequ since there is sufficient interval between the crushing season and the planting. Complete stoppage of aeration after the initial rise of tempera is most beneficial for conserving nitrogen and dry matter, as in groups I III. Placing the heaps in trenches is better than when composting is don the ground.

Of these four methods, group I gives the best results and even this sh not be very expensive. Any pit already available could be used in the fact and even otherwise, the expense of digging the pits would have to be incu only once and there would be no recurring expenses, no turning being requ at any time during the formation of the compost. These pits could be over and over again during a number of years. The saving in loss of nitr and of dry matter would more than repay the initial cost of making trenches.

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STUDIES ON STORED GRAIN PESTS IN THE PUNJAB

†II. BIOLOGY OF *BRUCHUS ANALIS* FAB. AND *BRUCHUS CHINENSIS* LINN. (*BRUCHIDAE* : *COLEOPTERA*)

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(With three text-figures)

Introduction

BRUCHIDAE contains more than a 100 injurious species which occur in different parts of the world. Chittendon [1912], Garman [1917], Back [1930] and Bridwell and Bottimer [1933] have described seven species which are destructive to beans and peas in the United States of America. Bridwell [1918, 1920] has listed 11 injurious species from the Hawaii Islands ; two of which were collected from imported seed. Skaif [1918, 1926] mentioned 3 species destructive to various leguminous seeds in South Africa. Wilson [1931] has found 12 species in Great Britain associated with seeds of garden plants. Zacher [1931, 1936] considers seven Bruchid species to be pests of stored products in Germany. Bonder [1936] has recorded 50 destructive species from Brazil. Bekman [1929] has mentioned 11 injurious species which he collected from imported seed in Russia. Ghosh [1937] has named four species to be harmful to various pulses in Burma. In India the following 11 injurious Bruchids have so far been recorded [Lefroy, 1919 ; Fletcher, 1916, 1917, 1923 ; Kunhi Kannan, 1912 ; Kasergod, 1919 ; Fletcher and Ghosh, 1919 ; Champion, 1919] : *Bruchus quadrimaculatus* Fab., *Bruchus affinis* Froel, *Bruchus phaseoli* Gyl., *Bruchus caeruleus* Champ., *Bruchus maculipyga* Champ., *Bruchus theobromae*, *Bruchus pisorum* Linn., *Bruchus emarginatus* All., *Bruchus analis* Fab., *Bruchus chinensis* Linn. and *Rhaphymerus gonagra* Fab. In the Punjab, we have so far collected only the three last-named species. Some of these Bruchids confer serious injuries

*I. Observations on the reactions of the Dermestid beetle, *Trogoderma khapra* Arr., Wght. *Indian J. Ent.* **1**, 57—63 (1939)

†Read at the 28th session of the Indian Science Congress held at Benares, January 9

on pulses and gram in storage. According to Fletcher and Ghosh [19 generation after generation of *Bruchus chinesis* L. occur in the seed until t is hardly anything left of them. But in spite of their destructiveness and v distribution practically nothing is known about them in India, and espec so in the Punjab. Because of their importance, studies on the biology *Bruchus analis* F. and *Bruchus chinensis* L. were taken up and the res are presented in this paper.

Bruchus analis F.

Distribution. *B. analis* F. has a limited distribution : so far it has b recorded from Germany, Rhodesia, Burma and India only. In India it been collected from cowpeas and dried pulses in Mysore by Kunhi Kannan Fletcher [1919, 1923] and from Ajnala, Banga, Gurdaspur, Gurgaon, Jh Jullundur, Karnal, Lahore, Lyallpur, Multan, Palampur, Panipat, Raiw Rohtak, Shergarh, and Sheikhupura in the Punjab by us.

Food. It feeds on a fairly wide variety of stored grains. Ghosh [1 collected it from the following :—*moong* (*Phaseolus mungo*), *lobia* (*Phase calcaratus*), *mash* (*Phaseolus radiatus*), *moth* (*Phaseolus aconitifolius*), (*Pisum sativum*), cowpeas (*Vigna catjang*), pigeon-peas [*Cajanus c* (*indicus*)], large white beans (*Dolichos lablab*), gram (*Cicer arietinum*), bean (*Glycine hispida*) and sword bean (*Canavalia ensiformis*). In the Pun it is a major pest of *moong*, *mash*, *moth*, peas and *lobia*.

Life-history

Copulation. Copulation takes place immediately after emergence f the pupæ. Before the intimate connection is established the pair indu in horse-play ; the female runs away from the amorous male which, persisting in its chase, receives a vigorous kick from its stouter spo Undaunted, the male resumes the chase again and after experiencing s more rebuffs ultimately succeeds in getting on to the back of the fe and mating. During mating male stands in an upright position by suppor itself on its hinder pair of legs and the last abdominal segments which modified for the purpose. After mating the female throws off the male to ground where it lies on its back, the female in the meantime pulling out aedagus gradually with its own hinder pair of legs. According to Gh [1937] copulation lasts for five to nine minutes ; we, however, found it to from 2·75 minutes to 17·5 minutes.

Oviposition. Females began to lay eggs singly or several of them toge on the same grain any time within 72 hours of mating. Oviposition pe varied from two to six, and four to twelve days during May to Septem and December respectively, depending upon temperature (Table I). A si female laid 11 to 150 eggs at the rate 1 to 82 eggs per day. The hig number of eggs were laid in August (an average of 95 eggs per female) least in July and December (an average of 62·0 and 64·3 eggs per female pectively). Table I gives the oviposition period and the total nu of eggs laid by a female in her life-time and daily for each month from Ma to December.

TABLE I

Oviposition record of Bruchus analis *Fab.*

Month	Number of Observations	Total number of eggs laid			Number of eggs laid daily			Oviposition period in days		
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
rch to April	14	44	119	87·6	4	40	14·4	3	9	6·0
y	21	56	118	89·0	1	56	24·8	2	6	3·75
ie	14	50	103	83·9	1	82	23·3	3	5	3·40
y	15	11	90	62·0	2	72	18·0	2	5	3·40
gust	17	55	150	95·0	2	68	23·7	3	6	4·0
tember	13	63	105	75·0	2	65	21·0	3	5	4·1
tober	10	39	113	91·2	1	50	15·7	3	8	5·8
vember	10	64	115	88·3	3	41	16·0	6	8	6·8
cember	10	50	85	64·3	1	31	8·5	4	12	7·5

During May to September a female died immediately, but during April id October to December she lived for two to five days, after laying its last g.

Hatching. Duration of the egg-stage varied with the season : eggs laid in ay to August hatched in three to six days, those laid in April, September id October in four to eight days while those laid in November and December ok 8 to 13 and 18 days respectively to hatch (Table II). On hatching, e larva bored directly into the grain by cutting out a hole in that side of the g-shell which was in contact with the grain. Frass produced by the larva making its bore accumulated in the empty egg-shell which remained sticking the grain after hatching.

TABLE II

Duration of the egg-stage of Bruchus analis *Fab.*

Month	Number of observations	Duration of egg-stage (in days)			Remarks
		Minimum	Maximum	Average	
rch to April	1227	4	8	6·3	
y	1869	3	5	4·0	
ne	1188	3	4	3·7	
ly	928	3	5	3·7	
gust	1617	3	6	4·2	
tember	1370	4	7	5·3	
tober	912	6	8	6·5	
vember	806	6	13	6·5	
cember	386	..	..	18·0	Only two observations ; eggs hatched simultaneously

Viability of eggs. Viability of eggs is presented graphically in Fig. 1. It was its highest in May and lowest in August and during the active period (April October) it was found to be inversely proportional to relative humidity.

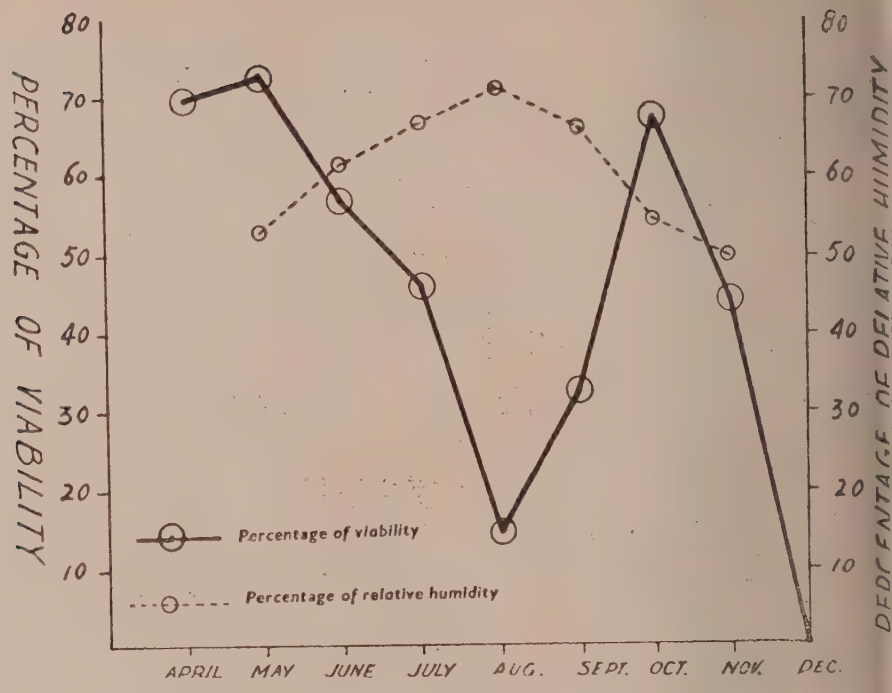

FIG. 1. Viability of eggs of *Bruchus analis* F. in different months

Larval stage. The entire larval stage was passed inside a grain. Whe full-fed, the larva migrated towards the periphery and came to lie next to th seed coat where it pupated. Duration of the larval stage during differen months is given in Table III.

TABLE III

Duration of the larval stage of B. analis *Fab.*

Month	Number of observations	Larval stage in days		
		Minimum	Maximum	Average
April	343	12	25	17·4
May	824	9	31	13·4
June	605	9	24	13·4
July	391	9	26	13·7
August	209	8	21	12·5
September	432	9	30	15·7
October	321	11	27	17·9
November	367	16	31	23·6
December	108	26	43	35·4

It will be observed from Table III that the duration of the larval stage s the shortest during June to September and longest in December. The pest assed the winter as hibernating larvæ and it was observed that all those arvæ which hatched on and after the middle of November entered into ibernation. A few typical cases of the duration of the over-wintered arvæ are presented in Table IV.

TABLE IV

Life of the over-wintered larvæ

Date of hatching	Date of pupation	Life of the over-wintered larvæ (in days)
1 October 1940	22 March 1941	152
8 October 1940	22 March 1941	145
1 November 1940	23 March 1941	112
4 November 1940	22 March 1941	129
1 November 1940	15 March 1941	103
3 December 1940	7 March 1941	96

Pupal stage. Pupal stage, like the larval stage, was also passed inside the rain. Duration of the pupal stage in different months of the year is given in 'able V.

TABLE V

Duration of the pupal stage of B. analis *F.*

Month	No. of observations	Duration of pupal stage (in days)		
		Minimum	Maximum	Average
Iarch	114	8	23	15·6
pril	293	5	14	7·3
Iay	523	6	14	8·3
une	392	6	13	8·2
uly	281	5	14	8·4
ugust	165	5	11	7·5
eptember	186	6	13	7·4
)ctober	172	7	15	10·5
Tovember	196	12	23	18·9
)ecember	119	14	36	22·3

It will be observed from the above table that the pupal stage is completed, n an average, in about 7·5 days during August to September and in 22·3 ays during December.

Longevity of adults. The female adults, on an average, lived for 4·8 days uring May to July and 16·1 days in December. The males lived longer than he females, i.e. for 6 to 20·4 days.

TABLE VI

Longevity of males and females in different months

Month	Number of Observations	Longevity of female adults (in days)			Longevity of male adult (in days)		
		Minimum	Maximum	Average	Minimum	Maximum	Ave
April	14	5	11	8·0	6	13	
May	19	3	7	4·8	5	8	
June	17	3	7	4·8	3	9	
July	15	3	7	4·8	5	11	
August	10	3	7	5·3	5	10	
September	13	4	7	5·7	7	10	
October	10	5	11	7·4	9	14	11
November	10	7	12	9·5	12	12	1
December	10	6	22	16·1	11	30	2

Seasonal history and number of generations. The females appeare March when they laid eggs; the earliest date on which the adults eme was March 6. The annual calendar of activities of the pest is given below

March . . . . . Activity of the pest begins

April to August . . . All stages of the pest present. Damage by it a maximum

September . . . . All stages present but its activity shows distinct de

October . . . . All stages present, activity greatly reduced, some o larvæ which hatch out in the last week hibernation

November . . . . All stages present, activity very much reduced, larvæ hatching on November 15 and after hibernation

December . . . . All stages present, activity at lowest ebb, eggs do hatch

January to February . . Hibernating larvæ only present, activity nil

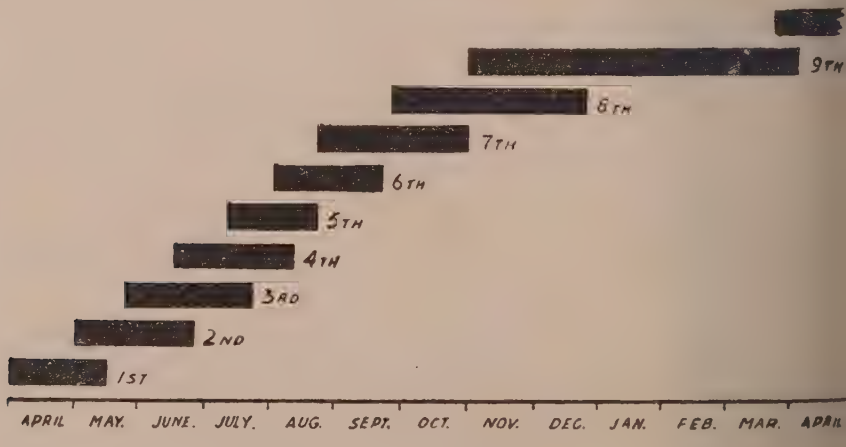

FIG. 2. Number of generations of *B. analis* F.

During March to December the pest passed through nine to ten overping generations (Fig. 2).

Sex ratio in different generations. Sex ratio varied in different generations at different times of the year. In the first, second, third, fourth, ninth tenth generations (i.e. during April to July, November to March) females dominated and in the fifth and sixth generations (i.e. from July to Septem-) males predominated but in the seventh and eighth generations (Septem- to October) the female and male population was at par.

The sex ratio of *B. analis* Fab. in different generations is given in Table .

TABLE VII

Sex ratio of B. analis *Fab. in different generations*

No. of generations	Total number of insects counted	Number of males	Number of females	Sex ratio	
				Male	Female
	363	150	213	41·3	58·7
	814	321	493	39·4	60·6
	353	136	217	38·6	61·5
	333	159	174	47·7	52·3
	186	107	79	57·5	42·5
	74	44	30	59·4	40·6
	280	140	140	50·0	50·0
I	552	275	277	49·8	50·2
	137	58	79	42·3	57·7
	237	103	134	43·4	56·6

Development in various leguminous seeds. Development of the pest was tied in the following 11 leguminous seeds :—*moong* (*Phaseolus mungo*), *h* (*Phaseolus aconitifolius*), gram [both *desi* and *kabuli* (*Cicer arietinum*)], s (*Pisum sativum*), *lobia* (*Phaseolus calcaratus*), *mash* (*Phaseolus radiatus*), *r* [*Cajanus cajan* (*indicus*)], lentil (*Lens esculenta*), *sem* (*Dolichos lablab*) *guara* (*Cyamopsis psoralioides*). It failed to breed on *sem* and *guara*. On il, out of 100 eggs laid and hatched, only one larva was able to attain the lt stage. The shortest duration of the larval and pupal stages was erved on *lobia*, *arhar*, *moth*, *kabuli* gram and *moong;* and longest *nash*. *Lobia* appeared to be its most favoured food. Ghosh [1937]

observed that cowpeas were liked most by this insect since the duration its life-cycle was shorter on it as compared to that on *Cajanus cajan* (*indicu* *Dolichos* and *Phaseolus mungo*.

TABLE VIII

Comparative rate of development and percentages of larvæ and pupæ completi their growth successfully on different seeds

Food	Duration of combined larval and pupal stages (in days)			Percentages of larv and pupæ completi the stage successful
	Minimum	Maximum	Average	
Moong	17	45	27·5	72·1
Mash	19	59	41·5	76·1
Moth	17	34	25·7	70·1
Kabuli gram	18	45	25·8	73·3
Desi gram	30	44	36·9	10·9
Peas	20	44	32·1	54·6
Lobia	13	45	22·8	87·8
Arhar	17	33	24·1	65·7

Nature and extent of damage. On hatching, the larvæ bored into t seed and by the time they completed their development, they consum the entire contents of the grain, leaving only the outer shell behind: t adults escaped by cutting out a circular hole in this shell. As generati after generation was passed in quick succession during the active season, a as only one larva was found in a single grain, the entire quantity of stor grains was found to be reduced to a mass of hollowed-out seeds each wit circular hole at one end. When grain was stored in air-tight receptacles foul smelling fungus also developed on the seeds.

Bruchus chinensis Linn

Distribution. B. chinensis L. is of world-wide distribution. It is report from the United States of America, Mauritius, Hawaii, England, Germa Porto Rico, Rhodesia, Santo-Domingo, Formosa, Africa, China, Philippi Japan, Java, Ceylon, Burma and India. In the Punjab, we have collect it from Panipat, Multan, Karnal, Gurgaon, Jhang, Palampur, Banga a Lyallpur.

Food. In the Punjab it has been found damaging gram (*Cicer arietinu* *moong* (*Phaseolus mungo*), *moth* (*Phaseolus aconitifolius*), *mash* (*Phaseo* *radiatus*), *lobia* (*Phaseolus calcaratus*), peas (*Pisum sativum*), cowpeas (*Vig* *catjang*), lentil (*Lens esculenta*) and *arhar* [*Cajanus cajan* (*indicus*)]. Elsewh it has also been recorded doing damage to chicken pea, *sem* (*Dolichos labla* *Dolichos biflorus*, soy bean (*Glycine hispida*), chickling vetch (*Lathyrus sativ* *Vicia faba*, *Arachis hypogaea*, cotton bolls, cotton seeds, sorghum, millet a maize.

history

Copulation. Copulation takes place immediately after emergence, the s remaining in coitus for 4·8 to 16 minutes.

Oviposition. Females started laying eggs next day after copulation, mode of oviposition being identical with that of *B. analis* F. Usually e than one egg were laid on a single grain of gram and, unlike *B. analis*, or three larvæ were found to develop in their individual chambers in ame grain. A single female laid 34 to 113 eggs at the rate of 1 to 37 eggs day. The highest number of eggs were laid in May and October and in April, June, July and December. Table IX gives oviposition record is pest.

TABLE IX

Oviposition record of B. chinensis *L.*

Month	Number of Observations	Total number of eggs laid			No. of eggs laid daily		
		Minimum	Maximum	Average	Minimum	Maximum	Average
	16	34	85	55·2	1	9	6·0
	17	66	111	90·4	1	37	16·0
	18	39	94	62·7	2	33	12·0
	15	35	83	67·0	1	31	11·3
	16	39	99	74·3	1	23	13·2
ber	15	46	104	87·7	1	24	11·7
r	15	56	113	92·6	1	24	9·4
ber	8	54	95	69·2	1	13	4·9

Hatching. Egg stage occupied seven to fourteen days in April, four to ays in September, and eight to sixteen days in November.

TABLE X

Duration of the egg-stage of B. chinensis *L.*

Month	No. of observations	Duration of egg-stage (in days)		
		Minimum	Maximum	Average
	596	7	14	9·5
	48	5	9	6·5
	62	6	9	7·2
	43	6	9	6·8
st	225	4	7	5·7
nber	729	4	6	4·8
er	593	5	9	7·0
nber	151	8	16	13·1

Larval stage. Larval stage was passed inside the grain. When full-n, the larva migrated towards the periphery of the grain and rested just uth the seed coat. Duration of the larval stage was the shortest in gst and September and the longest in November (Table XI).

TABLE XI

Duration of the larval stage of B. chinensis *L.*

Month	No. of observations	Duration of the larval stage (in days)		
		Minimum	Maximum	Average
April	30	17	21	18·
May	40	12	33	20·
June	19	14	20	17·
July	71	14	26	16·
August	266	10	21	12·
September	586	10	21	13·
October	313	14	30	20·
November	21	26	38	34·

The pest hibernated as larva from October onwards. Hibernati usually began on October 10 and reached its climax on 15 when all the lar which hatched on this date and after hibernated. In all 423 larvæ w kept under observation and 62·4 per cent of this lot over-wintered and emerg as adults successfully. A few typical cases of the duration of the ov wintered larvæ are given in Table XII.

TABLE XII

Life of the over-wintered larvæ.

Eggs hatched on	Larvæ pupated on	Life (in days) of th over-wintered larvæ
14 October 1940	15 March 1941	152
14 October 1940	27 March 1941	164
17 October 1940	15 March 1941	149
20 October 1940	6 April 1941	168
21 October 1940	15 March 1941	145
4 November 1940	15 March 1941	131
4 November 1940	3 April 1941	150
13 November 1940	27 March 1941	134
21 November 1940	23 March 1941	122
28 November 1940	27 March 1941	120
2 December 1940	29 March 1941	117
2 December 1940	3 April 1941	122

Pupal stage. Pupal stage was also passed inside the grain, the adul escaping from the grain by cutting out a circular hole in the seed coat. Dur tion of the pupal stage in different months is given in Table XIII.

TABLE XIII

Duration of the pupal stage of B. chinensis *L.*

Month	No. of observations	Duration of pupal stage (in days)		
		Minimum	Maximum	Average
May	375	6	13	8·1
June	31	6	9	7·9
July	56	5	8	6·4
August	162	4	9	6·4
September	543	6	15	8·9
October	348	8	18	11·9
November	101	15	28	18·2

Longevity of adults. Females lived longer than the males. Longevity of the adults in different months of the year is given in Table XIV.

TABLE XIV

Longevity (in days) of adults in different months

Month	No. of observations	Male			Female		
		Minimum	Maximum	Average	Minimum	Maximum	Average
April	16	6	17	10·7	6	18	13·0
May	17	6	9	7·0	5	8	6·4
June	18	3	9	6·1	4	8	6·2
July	15	5	7	6·1	5	8	7·1
August	16	5	7	5·9	5	8	6·5
September	15	5	12	7·4	5	12	8·4
October	15	6	12	9·7	9	12	10·6
November	8	12	20	16·2	13	20	15·5

Seasonal history and number of generations. The adults began to appear towards the end of March, the earliest date of their appearance being 26. Seasonal history is given below :

March	Adults emerge towards the end
April to September	All stages of the pest are present. Damage by it is at its maximum. In May to July viability of the eggs falls considerably
October to November	All stages present, activity reduced. Some larvæ begin to hibernate
December to February	Hibernating larvæ only present

The pest passed through seven to eight generations in a year which overlaped (Fig. 3)

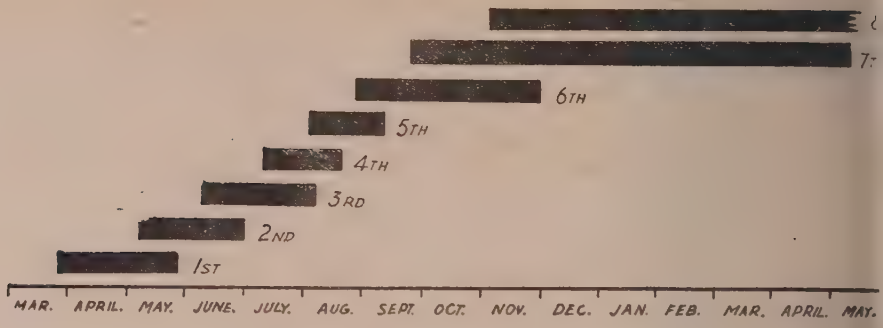

FIG. 3. Number of generations of *B. chinensis* L.

Sex ratio in different generations. The males, as is seen from Table XV predominate in all the generations.

TABLE XV

Sex ratio of B. chinensis *L. in different generations*

No. of generation	Total number of insects counted	Number of males	Number of females	Sex ratio	
				Male	Female
I	864	453	411	52·4	47·6
II	2756	1508	1248	54·7	45·3
III	2592	1423	1169	54·9	45·1
IV	2437	1449	988	59·5	40·5
V	4692	2622	2070	55·9	44·1
VI	7295	3765	3530	51·6	48·4
VII	3204	1683	1521	52·5	47·5

Development in various leguminous seeds. Development of the pest wa studied in the following 11 leguminous seeds : *moong* (*Phaseolous mungo*) *moth* (*Phaseolus aconitifolius*), gram both *desi* and *kabuli* (*Cicer arietinum*), pea (*Pisum sativum*), *lobia* (*Phaseolus calcaratus*), *mash* (*Phaseolus radiatus*), *arha* [*Cajanus cajan* (*indicus*)], lentil (*Lens esculenta*), *sem* (*Dolichos lablab*) an *guara* (*Cyamopsis psoralioides*). It failed to breed in *sem* and *guara*. I developed most quickly in *moth*, *lobia*, *moong*, and very slowly in *mash* an peas. It laid the least number of eggs on lentil. Ghosh [1937] observed th shortest duration of this insect in pigeon-peas [*Cajanus cajan* (*indicus*)] whic was also found by him to suffer most from its ravages. Table XVI give

ıe comparative rate of development and oviposition of this pest along with e percentages of larvæ and pupæ completing their growth successfully in fferent seeds.

Table XVI

omparative rate of development, oviposition and percentages of larvæ and pupæ completing their growth successfully in different seeds

Variety of grain	Duration of larval and pupal stages (in days)			No. of eggs laid			Viability of the larval and pupal stage
	Minimum	Maximum	Average	Minimum	Maximum	Average	
ıbuli gram	22	31	26·5	58	89	78·0	92·4
si gram	20	29	24·9	52	97	77·4	91·9
as	25	66	43·3	53	101	79·0	42·3
har	21	26	23·3	66	106	81·8	95·8
oong	20	27	22·1	58	105	77·8	97·9
oth	21	24	21·6	66	82	73·0	96·9
ntil	22	36	26·6	51	70	61·3	65·0
ash	36	49	43·0	32	100	63·4	87·6
bia	21	25	21·6	60	90	77·0	93·3

Nature and extent of damage. Nature and extent of damage was found to e identical with that of *Bruchus analis* F. In a single grain there were ound as many as eight larvæ.

Natural enemies

Both the insects were found to be parasitized by *Bruchobius laticeps* shm. (family, Miscogasteridæ) Order Hymenoptera in their larval stages. Ve collected this parasite from Panipat, Karnal, Shergarh, Lahore, Lyallpur nd Jhang.

Summary

Bruchus analis F. and *Bruchus chinensis* L. are the two important pests of arious stores, pulses and gram in the Punjab. The former remains active om March to November whereas the latter is active from March to October. he eggs are glued to the grain and the larva on hatching bores into the seed nd feeds on its contents. When full grown, it migrates towards the periphery nd comes to lie next to the seed coat where it pupates. The adult emerges y cutting out a circular hole in the seed coat.

In the case of *B. analis* F., a single female lays 11 to 150 eggs in 2 to 12 ays at the rate of 1 to 82 eggs per day. Incubation period lasts from 1 to 8 days, larval stage occupies 8 to 43 days and pupal stage is completed n 5 to 36 days depending upon season. Males live longer than the emales. There are 9 to 10 generations in a year and these overlap.

A single female of *B. chinensis* L. lays 34 to 113 eggs at the rate of 1 to 7 eggs per day. Eggs hatch in 4 to 16 days, larvæ are full grown in

10 to 38 days, whereas pupal stage occupies 4 to 28 days. Longevity the female adult varies from 4 to 20 days and that of male from 3 to days. The insect passes through seven to eight overlapping generat in a year.

Development of these insects on 11 different leguminous seeds is also cribed. The larvæ of both these insects are parasitized by *Bruchobius lati* Ashm.

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TUDIES ON THE QUALITY OF JAYWANT COTTON GROWN FROM SEEDS OBTAINED FROM DIFFERENT STAGES OF PROPAGATION

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N order to maintain the purity of improved varieties of cotton, a subsi-dized scheme 'Maintenance of the nucleus of pure seed' is established by the dian Central Cotton Committee, Bombay. For this purpose, the practice lowed in the Southern Maratha Country is to sow in two-acre plot, on the harwar Farm, seed of a particular variety inbred by the Cotton Breeder. e plants in this stage known as stage I are selfed, the inbred bolls are picked pa[r]ately and ginned and the seed is then multiplied on the same farm as ll as in Dharwar taluka on an area of about 25 acres at each of these places. e produce of this seed is known as stage II and is handed over to the Cotton perintendent from the farm for multiplication in all the cotton centres by gistered growers under expert supervision. The plants of the succeeding ops are harvested and ginned under supervision so as to eliminate all ances of admixture with foreign seed. This ensures a fairly high degree of rity in the seed which ultimately reaches the farmers' hands and as the ocess is continuous, the deterioration by mixture can hardly take place.

It may, however, be noted that during the first and second stages, there i rigid control over the purity of the seeds, but due to the numerous uncon-llable factors in the districts, the cotton may not remain quite pure in sequent stages. The roguing of foreign cotton plants is done up to the rth stage and the number of plants removed per acre are on an average about 0·5 and 1·3 per cent in the third and fourth stages, respectively.

It may be mentioned that the produce up to the fifth stage only is under l control of the Agricultural Department and the area under Jaywant cotton that stage is 1,18,000 acres. The produce of this area is considered suffi-nt for sowing about 12,00,000 acres which is the total area under Kumpta tton. Thus, the sixth stage from which deterioration takes place is left out.

It should not be forgotten that there are chances of admixture from the all area of different varieties of cotton grown in Bijapur, Dharwar and Belgaum districts and due to importation of cotton from the Nizam's Domi-ions as well.

Thus, the chances of mixture are :—(1) Natural cross pollination, (2) chanical mixture when handled from the field to the seed sowing stage ch as heaping the *kapas* (seed cotton) in factories, ginning in factories and rage of seed.

Object of the investigation

Jaywant cotton is grown on about 12,00,000 acres in the Bombay-Kar tak. The extensive cultivation of this variety has been possible on acco of its superiority in the economic characters over other local varieties. Th was, however, an impression (not based on scientific evidence) that the from later stages deteriorated in quality. The investigation was, theref undertaken to study the variations of fibre and agronomic characters of cotton grown from seeds obtained from different stages of multiplication the results are presented in this paper.

Material and method

The experiment was conducted on the Dharwar Farm on an are about half an acre. Inbred seed was obtained from the Cotton Bree second stage from the Superintendent, Dharwar Farm, and the seed of l stages, i.e. from third to sixth was supplied by the Cotton Superintend from the Hubli centre, which is the biggest centre in the whole tract, and results are, therefore, applicable to the whole of the Kumpta tract. The samples of each stage were sufficient for sowing about three *gunthas* and considered representative of each stage. The experiment was commer in 1938-39 season and was continued in the next year. During these seasons, the seed of all the six stages was sown in duplicated plots yiel 12 samples for each season. Two representative samples, each weighing a two pounds of *kapas* of each stage from the second picking were obtained.

The problem was studied from the following points of view and the meth and procedure followed were the same as adopted at the Technological Lab tory, Mutanga, for measuring the different fibre characters. The matu ratio and standard hair-weight were calculated by using the formula der by Pierce and Lord [1934]. The number of fibres were also calculated f the values of fibre length, fibre-weight and weight of lint per seed.

Fibre characters :

(1) Mean fibre length in inches
(2) Fibre-weight per unit length
(3) Fibre maturity
(4) Maturity ratio
(5) Standard hair-weight

Agronomic characters :

(1) Ginning percentage
(2) Lint index
(3) Number of fibres per seed

xperimental results :

The results of fibre and agronomic characters of Jaywant cotton gr from seeds obtained from different stages of propagation are given in Tab and II.

TABLE I

Fibre characters

Season	Stage I		II		III		IV		V		V	
	1	2	1	2	1	2	1	2	1	2	1	
					1. Mean fibre length (inches)							
38-39 .	0·91	0·90	0·90	0·89	0·91	0·91	0·91	0·92	0·91	0·91	0·91	0·91
39-40 .	0·91	0·94	0·93	0·91	0·92	0·91	0·91	0·91	0·91	0·92	0·90	0·91
					2. Mean fibre-weight per unit length							
38-39 .	0·171	0·177	0·178	0·163	0·173	0·170	0·179	0·174	0·183	0·178	0·188	0·190
39-40 .	0·182	0·182	0·189	0·190	0·190	0·187	0·193	0·198	0·191	0·183	0·207	0·202
					3. Fibre maturity (per cent mature hairs)							
38-39 .	68	67	67	62	64	66	64	63	67	69	67	71
39-40 .	67	65	68	69	65	65	64	67	66	67	69	67
					3. Fibre maturity (per cent immature hairs)							
38-39 .	23	24	22	26	25	24	24	26	24	21	21	21
39-40 .	23	24	22	21	25	23	25	23	24	22	22	22
					4. Maturity ratio							
38-39 .	0·957	0·951	0·958	0·930	0·939	0·948	0·943	0·933	0·951	0·967	0·961	0·972
39-40 .	0·954	0·945	0·961	0·967	0·942	0·949	0·939	0·954	0·948	0·958	0·963	0·956
					5. Standard hair-weight							
38-39 .	0·178	0·186	0·185	0·175	0·186	0·179	0·190	0·186	0·192	0·184	0·196	0·195
39-40 .	0·191	0·192	0·196	0·196	0·202	0·197	0·205	0·207	0·202	0·191	0·215	0·211

TABLE II

Agronomic characters

Season	Stage I		II		III		IV		V		VI	
	1	2	1	2	1	2	1	2	1	2	1	2
					1. Ginning percentage							
38-39 .	29·9	30·5	30·5	30·2	29·0	29·0	29·5	29·7	29·5	29·2	28·6	29·0
39-40 .	29·5	30·4	29·0	30·7	28·6	29·4	27·5	27·0	28·2	29·8	27·0	27·5
					2. Lint index							
38-39 .	2·70	2·80	2·74	2·69	2·56	2·57	2·50	2·67	2·45	2·18	2·36	2·52
39-40 .	2·57	2·48	2·25	2·34	2·30	2·60	2·23	2·16	2·35	2·42	1·97	2·13
					3. Number of fibres per seed							
38-39 .	6170	6215	6050	6580	6390	5870	5400	5890	5380	4610	4910	5110
39-40 .	5480	5160	4500	4760	4670	5370	4460	4240	4780	5080	3740	4100

Discussion of results

The analysis of variance was applied to the results obtained for various fibre and agronomic characters of Jaywant cotton studied in t paper and the significance of the differences have been judged according this method. As the significant effect between different stages does not nec sarily indicate deterioration, the separation of linear component due to dete ration was also worked out to study the effect due to different stages of pro gation.

Table III

Summary of results

Fibre and agronomic characters	Stages						Average	Standa error
	I	II	III	IV	V	VI		
Fibre length	0·915	0·908	0·912	0·912	0·912	0·908	0·911	0·004
Fibre-weight	0·178*	0·180	0·180	0·186	0·184	0·197*	0·184	0·002
Percentage of mature hairs	67	66	65	65	67	68*	66·2	0·85
Maturity ratio	0·952	0·954	0·945	0·942	0·956	0·963	0·952	0·007
Standard hair-weight	0·187*	0·188*	0·191	0·197	0·192	0·204*	0·193	0·002
Ginning percentage	30·1*	30·1*	29·0	28·4	29·2	28·0*	29·1	0·292
Lint index	2·64*	2·51	2·51	2·39	2·35	2·25*	2·44	0·054
No. of fibres per seed	5756*	5472	5575*	4998	4962	4465*	5205	157

* Indicate significantly higher or lower values than the mean

The analysis of variance for fibre length, fibre-weight, percentage mature hairs, maturity ratio and standard hair-weight are given in Table IV.

From Table IV, it is evident that the variance due to stages is non-signi ficant for fibre length, percentage mature hairs and maturity ratio and th it is significant for fibre-weight per unit length and standard hair-weigh The standard hair-weight is calculated from fibre-weight ; the significa values for standard hair-weight can, therefore, be expected.

The analysis of variance results of fibre-weight and standard hair-weig were further examined and the analysis is given in Table V.

The linear component being significant for fibre-weight and standar hair-weight shows evidence of deterioration. But reference to Table I wi show that the values in the sixth stage are rather high during both the season It may be noted that higher fibre-weight means coarser cottons which in tur will give lower spinning value if all other fibre properties remain the sam Hence it can be seen that the cotton from the sixth stage is particularly in ferior as judged from the fibre-weight and standard hair-weight values. Thi is corroborated from the summary of results given in Table III where it can b observed that only the sixth stage values are significantly higher than the aver age.

Analysis of variance

(Fibre characters)

Sources of variation	Degrees of freedom	Fibre length		Fibre-weight		Percentage mature hairs		Maturity ratio		Standard hair-weight	
		Sum of squares	Mean square	Sum of squares	Mean square	Sum of squares	Mean square	Sum of squares	Mean square	Sum of squares	Mean square
Due to seasons	1	0·0004	0·00040**	0·001204	0·001204**	0·66	0·66	0·000028	0·000028	0·001247	0·001247**
Due to stages	5	0·0002	0·00004	0·000938	0·000188**	43·33	8·67	0·001170	0·000234	0·000844	0·000169**
Seasons × stages	5	0·0008	0·00016	0·000154	0·000031	24·84	4·97	0·000563	0·000113	0·000090	0·000018
Field error	12	0·0009	0·00008	0·000224	0·000019	35·00	2·92	0·000959	0·000080	0·000231	0·000019

** Denotes significance for 1 per cent level

TABLE V

Further analysis of variance

	Degrees of freedom	Fibre-weight		Standard hair-weig	
		Sum of squares	Mean square	Sum of squares	Mean square
Linear regression . .	1	0·000704	0·000704*	0·000641	0·0006
Deviation from regression .	4	0·000234	0·000058	0·000203	0·0000
Total (stages) . . .	5	0·000938		0·000844	

* Denotes significance for 1 per cent level

It is, therefore, apparent that there is no evidence for deterioration Jaywant cotton in the first five stages as judged by the various fibre char ters studied in this paper. The only variation is due to seasons with wh the present study is not concerned.

It may be observed that Jaywant cotton did not show any decline, fibre length, percentage of mature hairs and maturity ratio for different sta of propagation.

The fibre-weight values of 1938-39 season showed a tendency for the cott to become coarser and it is interesting to note that it is coarsest in the six stage for both the seasons. It may be noted that 1938-39 samples were fi than those of the other season and this may possibly be due to clima factors.

The standard hair-weight, which is a derived property, showed a slig increasing tendency in the successive stages for both the seasons, the six stage recording the highest values in both seasons. Like fibre-weight, the values are higher in 1939-40.

Agronomic characters

It can be seen from Table II that the result of the ginning percenta lint index and number of fibres per seed showed a decreasing tendency fr successive stages, the sixth stage giving the lowest values for both the seaso The number of fibres per seed is derived from fibre-weight and lint-ind values and as these are correlated to each other, the lower number of fibres the sixth stage can be ascribed to the higher fibre-weight values obtained f that stage. Needless to mention that the lower ginning percentage, li index and number of fibres per seed go to show deterioration.

The analysis of variance due to stages show significant variatio This was further examined and the analysis of variance is given in Table V

It can be seen from Table VII that the linear component is also significa for the agronomic characters studied indicating deterioration.

But like fibre characters, the results in Table III indicate that only the sixth stage, the ginning percentage is significantly lower than for oth stages. This is corroborated by the results of the lint index and number

es per seed which are significantly lower in the sixth stage only. It, therefore, seems evident that the agronomic characters also did not show any decline in the first five stages of propagation.

TABLE VI

Analysis of variance of agronomic characters

Sources of variation	Degrees of freedom	Ginning percentage		Lint index		Number of fibres per seed	
		Sum of squares	Mean square	Sum of squares	Mean square	Sum of squares	Mean square
Due to seasons	1	4·166	4·166†	0·3602	0·3602†	6237301	6237301†
Due to stages	5	14·283	2·86†	0·3857	0·0771†	4647180	929436†
Seasons × stages	5	4·194	0·84	0·1891	0·0378	1464631	293006
Field error	12	4·070	0·34	0·1408	0·0117	1177162	98096

† Denotes significance for 1 per cent level

TABLE VII

Further analysis of variance

Sources of variation	Degrees of freedom	Ginning percentage		Lint index		Number of fibres per seed	
		Sum of squares	Mean square	Sum of squares	Mean square	Sum of squares	Mean square
Linear regression	1	10·656	10·656†	0·3730	0·3730†	4194893	4194893†
Deviation from regression	4	3·627	0·907	0·0127	0·0032	452287	113072

† Denotes significance for 1 per cent level

CONCLUSIONS

Jaywant cotton grown on the Dharwar Farm from seeds obtained from six stages of propagation were examined for fibre and agronomic characters during 1938-39 and 1939-40 seasons. It is found that there is no evidence of deterioration in fibre length, fibre maturity and maturity ratio but there is a tendency for the cotton to become coarser, to give lower ginning percentage lower lint index and lesser number of hairs per seed during the later stages of propagation.

It is clear that there is no deterioration in the first two stages which are definitely pure and for the later stages where rigid control may not be possible, there is a slight tendency for the cotton to deteriorate. It may be noted that in respect of these characters, the values of the sixth stage are significantly

inferior to those of the other stages, indicating deterioration in the sixth s only. It may be stated that the Department is using the seeds up to the stage only whereafter visible deterioration takes place in the economic cha ters studied. The system of auction sale adopted in this tract is after grad and generally it is observed that the cotton up to the third stage does no into the lower grade which corroborates with the findings in this study. values of the maturity ratio, standard hair-weight and number of fibres seed are derived by calculation from fibre-weight and other measure characters.

Acknowledgements

The writer has pleasure in thanking Rao Bahadur S. S. Salimath for gesting the problem and Dr Nazir Ahmad for valuable suggestions and us directions. Mr R. S. Koshal was kind enough to go through the statist work involved in the paper. The Dharwar Farm Superintendent helped conducting the experiment and the Cotton Superintendent by supplying seeds of later generations. His special thanks are due to Mr M. L. P for going through the manuscript critically and for useful suggestions.

EFFECT OF LIMING ON THE TRANSFORMATION OF PHOSPHORUS IN ACID SOILS

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(With three text-figures)

THAT application of lime influences the quantity of available phosphorus in soils has been pointed out by several workers, both by laboratory nalysis and field experiments. Naftel [1937] showed that readily available osphorus by Truog's method was greatly increased (more than doubled) y the addition of lime. Askinazi and Yarusov [1928] showed that intro- tion of lime in a podsolized soil resulted in an accumulation of the mineral osphoric acid in the soil solution and an increased phosphate solubility n weak acids. Cook [1935] showed that the addition of lime to soils caused ificant increases in the amounts of readily available soil phosphates.

Sewell and Latshaw [1931] found that fertilization with superphosphates il not increase the percentage of phosphorus in alfalfa but that application lime with the superphosphate did. Albrecht and Klemme [1939] reported ld work conducted with lespedeza forage in which application of limestone d superphosphate almost doubled the calcium, phosphorus and nitrogen ntent of the crop over that obtained from superphosphate alone. Davis d Brewer [1940] found that liming soils low in calcium content enabled ter legumes to utilize larger quantities of the phosphorus supplied by super- osphate.

Very little is, however, known as to the precise nature of the transforma- n process and also as to the type of phosphorus compounds that contribute ards the increased availability. It has been suggested by some that a t of the iron and aluminium phosphates becomes soluble by chemical eraction with lime, while according to others it is due to the mineralization organic phosphorus compounds present in the soil. In a study of the ribution of different forms of phosphorus in some Indian soils it has been nd by the authors that acid soils are characterized by high accumulation organic phosphorus and also by a high percentage of iron and aluminium osphates. Transformation of one or both of these types of compounds ems to be the most probable thing to happen during the process of conver- n. The change in the soil reaction brought about by lime is of course a ndamental factor in both these kinds of transformation.

The object of this work was to find out the nature of transformation fected by liming, by determining the relative amounts of the different groups f phosphorus compounds by fractionating the soil with and without liming atments. The soil selected was a paddy soil from Titabari, Assam. The l of the soil is 4·7 and its content of P_2O_5 is 0·1145 per cent. The avail- le phosphorus is extremely low, it being 2·6 mg. P_2O_5 per 100 gm. of soil.

The liming materials used were chemically pure calcium carbonate, alcium hydroxide, calcium sulphate and magnesium oxide each at the rate f 2·5, 5 and 7·5 tons per acre.

Procedure

The general procedure adopted was as follows : 20 gm. samples of were weighed into wide-mouthed flasks and thoroughly mixed with the quisite amounts of liming materials. To each mixture enough distilled w was added to bring it to its optimum moisture content. The flasks v then weighed, stoppered with cotton plugs and stored in a dark room. Ev few days the flasks were aerated, reweighed and water added to compen for the loss due to evaporation. At intervals of 4, 6, 8 and 10 weeks, sam were withdrawn from the incubating flasks, air-dried and analysed for phosphorus fractions by the method of Dean [1938] as modified by Gl [1942]. The *p*H of the withdrawn samples was also determined at the s time. The treatment of the control was exactly the same except that lime was added to it. The amounts of different materials added were calcu ed on the basis of top six inches of soil weighing 2,000,000 lb. per acre of la

Each treatment was done in triplicate, but, as no appreciable varia could be observed in the results of the triplicate samples, the figures of sin analysis only were included in the study. The changes in the fractions v time, effected by the different treatments, are shown separately in Ta I, II, III, IV and V. For convenience of comparing the effectiveness different materials, the mean of the final increase or decrease over the c trol, as the case may be, in the three doses of dressings has been taken i account.

Table I

Change in acetic acid-soluble phosphorus with time due to liming

(Mg. P_2O_5 per 100 gm. of soil)

Treatment	Tons/ acre	4 weeks	6 weeks	8 weeks	10 weeks	Change in 10 weeks over control	Mea chan in 10 week
Control . . .	..	2·7	2·6	2·7	2·6	..	..
$CaCO_3$ . .	2·5	3·7	4·2	5·0	5·8	+3·2	
	5·0	3·9	4·6	5·2	5·9	+3·3	+3·
	7·5	3·7	4·9	5·3	6·5	+3·9	
$Ca(OH)_2$.	2·5	3·7	5·2	6·0	6·7	+4·1	
	5·0	4·2	5·2	6·2	6·3	+3·7	+4·
	7·5	4·1	5·6	6·3	6·8	+4·2	
$CaSO_4$.	2·5	3·5	4·9	5·6	6·0	+3·4	
	5·0	3·6	4·9	5·4	5·6	+3·0	+3·
	7·5	3·7	5·0	5·7	6·1	+3·5	
MgO . .	2·5	4·2	6·0	6·8	8·0	+5·4	
	5·0	4·3	5·9	7·0	7·8	+5·2	+5·
	7·5	4·4	6·8	7·1	8·2	+5·6	

TABLE II

Change in organic phosphorus with time due to liming

(Mg. P_2O_5 per 100 gm. of soil)

Treatment	Tons/acre	4 weeks	6 weeks	8 weeks	10 weeks	Change in 10 weeks over control	Mean change in 10 weeks
ntrol . . .	..	29·2	28·2	27·2	28·4	..	..
CO_3 .	2·5	28·6	28·0	25·8	20·6	—7·8	
	5·0	27·6	25·0	26·8	21·8	—6·6	—6·2
	7·5	24·6	23·5	21·4	24·0	—4·4	
$(OH)_2$.	2·5	25·8	23·4	23·0	23·8	—4·6	
	5·0	23·4	20·0	24·0	23·0	—5·4	—6·4
	7·5	21·4	20·4	18·8	19·2	—9·2	
SO_4 .	2·5	25·8	25·0	26·4	23·2	—5·2	
	5·0	25·5	27·0	23·5	22·0	—6·4	—5·1
	7·5	25·6	25·0	21·5	24·8	—3·6	
gO . .	2·5	24·0	22·0	22·0	16·2	—12·2	
	5·0	21·6	21·4	21·0	15·6	—12·8	—11·1
	7·5	21·4	23·0	21·0	20·0	—8·4	

TABLE III

Change in alkali-soluble inorganic phosphorus with time due to liming

(Mg. P_2O_5 per 100 gm. of soil)

Treatment	Tons/acre	4 weeks	6 weeks	8 weeks	10 weeks	Change in 10 weeks over control	Mean change in 10 weeks
ntrol . . .	..	33·3	33·3	32·8	32·6	..	..
CO_3 . .	2·5	31·4	30·0	35·2	34·5	+1·9	
	5·0	31·4	31·4	34·2	34·2	+1·6	+0·9
	7·5	32·5	32·5	37·6	32·0	—0·6	
$(OH)_2$.	2·5	33·6	34·1	32·0	31·2	—1·4	
	5·0	33·6	34·6	32·0	32·0	—0·6	—1·9
	7·5	34·6	34·6	32·0	28·8	—3·8	
SO_4 . .	2·5	32·5	32·0	33·6	32·8	+0·2	
	5·0	30·0	32·0	34·5	36·0	+3·4	+0·7
	7·5	31·4	32·0	34·5	31·2	—1·4	
gO . .	2·5	34·1	34·1	28·0	28·8	—3·8	
	5·0	33·6	34·6	28·0	29·6	—3·0	—3·8
	7·5	33·6	33·0	28·0	28·0	—4·6	

TABLE IV

Change in sulphuric acid soluble phosphorus with time due to liming

(Mg. P_2O_5 per 100 gm. of soil)

Treatment	Tons/ acre	4 weeks	6 weeks	8 weeks	10 weeks	Change in 10 weeks over control	Mean change in 10 weeks
Control	..	7·7	7·6	8·0	7·8	..	..
$CaCO_3$	2·5	7·8	7·2	8·2	7·6	—0·2	
	5·0	7·8	7·4	8·2	7·8	0·0	0·0
	7·5	7·8	7·4	8·2	8·0	+0·2	
$Ca(OH)_2$	2·5	7·6	8·2	8·8	8·6	+0·8	
	5·0	7·2	8·4	8·2	8·4	+0·6	+0·8
	7·5	8·0	8·0	9·0	8·8	+1·0	
$CaSO_4$	2·5	8·0	8·0	8·0	7·8	0·0	
	5·0	7·6	7·4	7·4	8·0	+0·2	—0·1
	7·5	7·8	7·6	7·8	8·2	—0·6	
MgO	2·5	7·2	8·2	9·2	9·0	+1·2	
	5·0	7·8	8·2	9·0	9·2	+1·4	+1·0
	7·5	7·6	8·2	9·2	8·4	+0·6	

TABLE V

Change in insoluble phosphorus with time due to liming

(Mg. P_2O_5 per 100 gm. of soil)

Treatment	Tons/ acre	4 weeks	6 weeks	8 weeks	10 weeks	Change in 10 weeks over control	Mean change in 10 weeks
Control	..	41·6	42·8	43·8	43·1	..	..
$CaCO_3$	2·5	43·0	45·1	40·3	46·0	+2·9	
	5·0	43·8	46·1	40·5	46·8	+3·7	+2·5
	7·5	45·8	46·2	42·2	44·0	+0·9	
$Ca(OH)_2$	2·5	43·8	43·6	44·7	43·2	+0·1	
	5·0	46·1	45·9	41·4	45·5	+2·4	+1·8
	7·5	46·4	45·9	48·6	46·1	+3·0	
$CaSO_4$	2·5	44·7	44·3	40·9	44·5	+1·4	
	5·0	47·8	43·2	45·6	42·2	—0·9	+0·8
	7·5	46·0	46·9	45·6	45·2	+2·1	
MgO	2·5	45·6	44·2	48·5	52·3	+9·2	
	5·0	47·2	44·4	49·3	52·3	+9·2	+8·4
	7·5	47·5	43·5	50·0	49·9	+6·8	

General discussion of results

The data in the above tables show that the only fractions that are much affected by the treatments are the acetic acid-soluble (available) phosphorus and organic phosphorus. No appreciable change could be observed in the other two fractions, namely the alkali-soluble inorganic phosphorus (iron and aluminium phosphates) and phosphorus soluble in $2N$ sulphuric acid (apatites). The effect of varying quantities of the materials on the amount of changes produced is, however, very slight. The higher doses usually seem to be a little more effective.

It will be seen from Table I that acetic acid-soluble phosphorus regularly increases with time up to a period of 10 weeks for all doses of $CaCO_3$, $Ca(OH)_2$, $CaSO_4$ and MgO. At the end of 10 weeks of incubation calcium carbonate has increased the fraction from the control value of 2·6 mg. to 6·1 mg., calcium hydroxide has increased it to 6·6 mg., calcium sulphate to 5·9 mg. and magnesium oxide to 8·0 mg. Magnesium oxide has trebled the quantity of available phosphorus, calcium hydroxide has increased it two and a half times while calcium carbonate and calcium sulphate have more than doubled it. It would thus appear that, of the four substances used, the effectiveness in increasing phosphate availability is of the order

$$MgO > Ca(OH)_2 > CaCO_3 > CaSO_4.$$

There is not much difference in the behaviour of the last two substances and for all practical purposes their effect may be taken to be almost identical. The rate of increase (average of three dressings) of available phosphorus with time is shown graphically in Fig. 1.

Table II shows that organic phosphorus decreases with time for all doses of dressings with the four substances in question. In 10 weeks calcium carbonate has reduced the amount of organic phosphorus by 6·2 mg., calcium hydroxide by 6·4 mg., calcium sulphate by 5·1 mg. and magnesium oxide by 11·1 mg. As before, the highest change has been effected by magnesium oxide; this has reduced the fraction by more than one-third its original value. The data presented in Table II indicate that the order of effectiveness in breaking down organic phosphorus is

$$MgO > Ca(OH)_2 > CaCO_3 > CaSO_4.$$

A comparison of Tables I and II will show that the decrease in organic phosphorus is not wholly accounted for by the corresponding increase in the available phosphorus. This is specially pronounced with magnesium oxide dressings. This would suggest that at least in the latter case a part of the phosphorus liberated by the decomposition of organic phosphorus combined in some other form which is not available. The diminution of organic phosphorus with time is shown graphically in Fig. 2.

It will also appear from Tables III and IV that alkali-soluble inorganic fraction (iron and aluminium phosphates) and sulphuric acid-soluble fraction (apatites) remain practically unchanged by the above treatments. The slight changes that have been produced in some cases are negligible in comparison with the amount of the fractions present in the soil. This would show that iron and aluminium phosphates do not contribute anything towards the increased availability caused by liming. The absence of any change in the

apatite fraction would also indicate that during the period of experiment
phosphorus has gone into apatite combination though calcium carbona
was present in excess in some of the treatments.

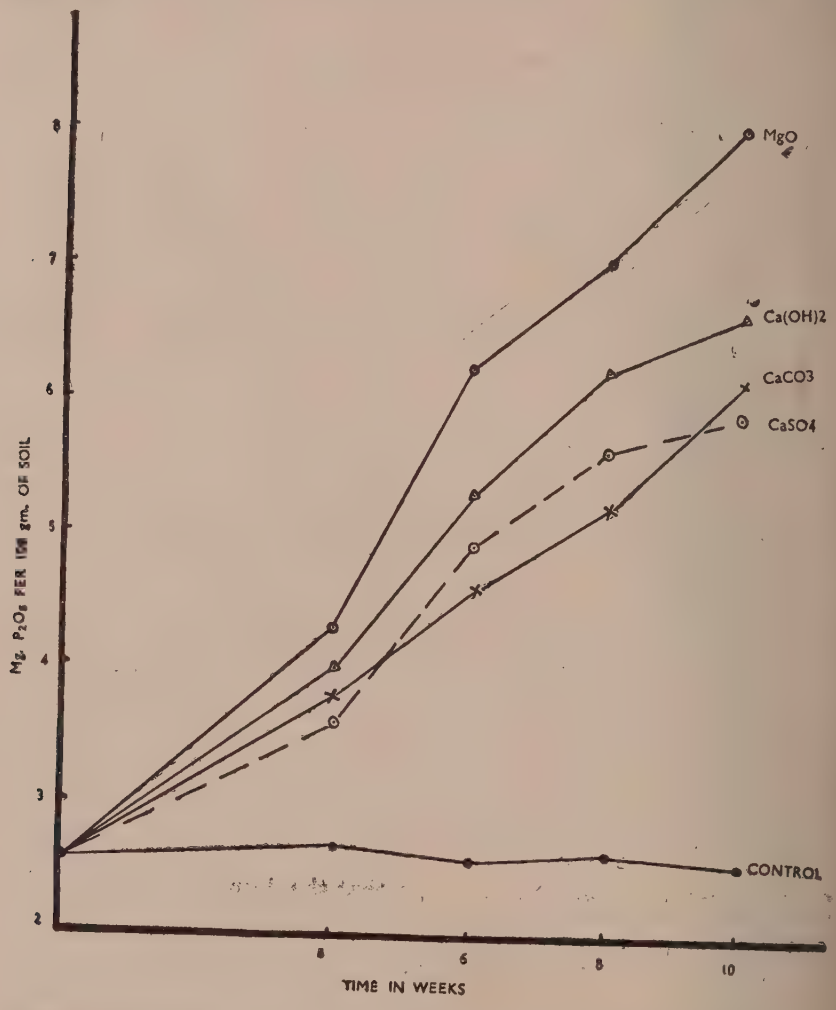

FIG. 1. Change in acetic acid-soluble phosphorus with time due to liming

The data in Table V represent the insoluble fraction, i.e. the difference between total phosphorus of the soil and the sum of the four phosphorus fractions determined. The treatments produced but little changes in this fraction except in the case of magnesium oxide. Magnesium oxide also caused a comparatively large decrease in organic phosphorus (Table II) all of which was not accounted for by the increase in the acetic acid-soluble fraction (Table I). In so far as it will permit a generalization it seems that with

gnesium oxide a part of the phosphorus liberated by the breakdown of anic phosphorus reverts to a highly inert combination. Dean [1938] nd that long continued applications of superphosphate and sulphate of monia at Rothamsted and Woburn did not increase this fraction in any preciable extent.

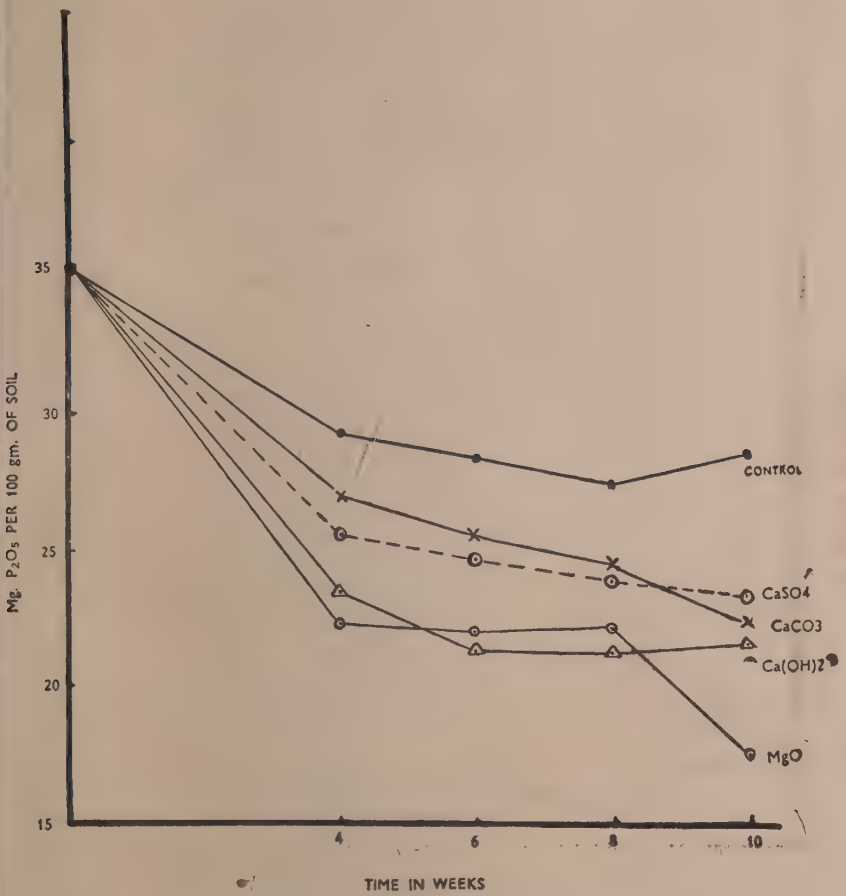

FIG. 2. Change in organic phosphorus with time due to liming

The change in the soil reaction with time brought about by the limin materials is shown in Table VI and Fig. 3. In all the treatments the *p*H o the media was increased, the higher doses showing slightly higher changes i all cases. In 10 weeks calcium carbonate shifted the *p*H from 4·7 to 7·2, alcium hydroxide to 7·9, calcium sulphate to 6·2 and magnesium oxide to 8·3. The order of effectiveness in increasing *p*H is, therefore,

$$MgO > Ca(OH)_2 > CaCO_3 > CaSO_4.$$

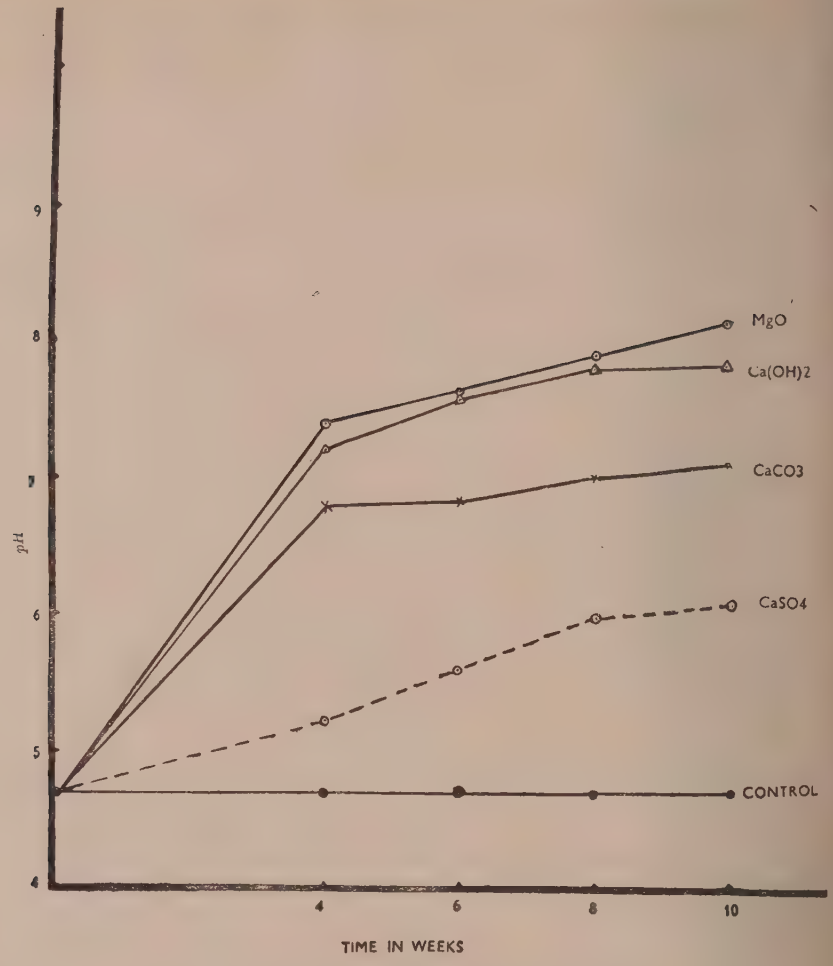

FIG. 3. Change in *p*H with time due to liming

Naftel [1937] using calcium carbonate at different calcium saturations ha shown that one month after liming the *p*H was increased from 4·7 to 7· at 75 per cent calcium saturation. A mixture of calcium carbonate an magnesium carbonate gave similar results. The reaction of the soil wa found to change linearly through the point of 75 per cent calcium satura tion and then approached a maximum of approximately *p*H 8·0 at the equili brium or saturation point.

It will also be seen that the materials stand in the same order in thei effectiveness in increasing *p*H and available phosphorus and in decreasin organic phosphorus. It would thus be evident that the extent of upwar shifting of the soil reaction is the principal factor in determining the degre of increased availability of soil phosphorus caused by liming. The chang

The soil reaction towards neutral conditions favours greater micro-biological activities which in turn effect greater breakdown of organic phosphorus compounds. The fact that any other fraction did not suffer any appreciable reduction by the treatments also shows that the increased availability may be ascribed solely to this cause.

TABLE VI

Change in pH with time due to liming

Treatment	Tons/acre	4 weeks	6 weeks	8 weeks	10 weeks	Change in 10 weeks over control	Mean change in 10 weeks
Control	..	4·7	4·7	4·7	4·7	..	..
CaO_3	2·5	6·5	6·6	6·8	7·0	+2·3	+2·4
	5·0	6·8	6·8	7·0	7·2	+2·5	
	7·5	7·0	7·1	7·1	7·1	+2·4	
$Ca(OH)_2$	2·5	6·9	7·4	7·6	7·5	+2·8	+3·0
	5·0	7·2	7·6	7·8	7·7	+3·0	
	7·5	7·5	7·8	7·9	7·9	+3·2	
CaO_4	2·5	5·0	5·3	5·9	6·1	+1·4	+1·4
	5·0	5·2	5·7	6·1	6·1	+1·4	
	7·5	5·3	5·9	6·1	6·2	+1·5	
MgO	2·5	7·2	7·4	7·8	7·8	+3·1	+3·4
	5·0	7·4	7·6	7·8	8·2	+3·5	
	7·5	7·6	7·8	8·0	8·3	+3·6	

SUMMARY

An acid soil, having a very low amount of available phosphorus was incubated with calcium carbonate, calcium hydroxide, calcium sulphate and magnesium oxide, each at the rates of 2·5, 5 and 7·5 tons per acre. Transformation of soil phosphorus was studied by fractionating the samples at intervals of 4, 6, 8 and 10 weeks.

The available phosphorus regularly increased with time in all the treatments at all doses. The order of effectiveness in increasing phosphate availability was

$$MgO > Ca(OH)_2 > CaCO_3 > CaSO_4.$$

The organic phosphorus decreased with time in all cases. The effectiv ness in decomposing organic phosphorus was of the order

$$MgO > Ca(OH)_2 > CaCO_3 > CaSO_4.$$

In all the treatments the *p*H of the soil was increased. The order effectiveness in increasing *p*H was $MgO > Ca(OH)_2 > CaCO_3 > CaSO_4$.

The treatments did not produce any significant change in the oth fractions.

The data reported show that the greater availability of soil phosphor caused by liming, as observed here and by previous workers, is due to t decomposition of organic phosphorus compounds and not due to chemic interaction of the liming materials with the phosphates of iron and aluminiu as supposed by some.

ACKNOWLEDGEMENT

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NOTES ON THE INDIAN SPECIES OF SUGARCANE LEAF-HOPPER, *PYRILLA* STAL. (LOPHOPINAE : FULGOROIDAE

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INTRODUCTION

THE genus *Pyrilla* is widely distributed throughout the oriental region. The known species of this genus have been described by different workers. Owing to a great variability of the individuals of the same species great confusion usually occurs in identifying these leaf-hoppers. Over and above this, there is a general resemblance between the individuals of different species This again causes a serious handicap for the field-worker to distinguish one species from the other.

The species of *Pyrilla* described by different workers are :—

P. lycoides Walker, *J. Ent.*, (i), [1862] ;
P. aberrans Kirby, *J. Linn. Soc. Zool.*, [1891] ;
P. perpusilla Walker, *List. Hom.*, (ii), [1851] ;
P. pusana Distant, *Ann. Mag. Nat. Hist.*, (8), 14, [1914] ;
P. protuberans Stal, *Ber. Ent. Zeitsch.*, 3, [1859] ;
P. sumatrensis Baker, *Treubia*, vol. 6, [1925.]

The Indian forms have been described by Distant in the *Fauna of British India—Homoptera*, vols. 3 and 6. He holds that three species of *Pyrilla*, viz. *P. aberrans*, *P. perpusilla* and *P. pusana* are distributed in various parts of the country. Later on Baker [1925] reviewed all the then known forms and described a new species from Sumatra (vide supra). The identification and validity of Indian species were questioned by a number of subsequent workers from different parts of India. Pruthi [1937] reviewed the problem of Indian species. He concludes that *P. aberrans* Kirby is unknown in India and that *P. perpusilla* and *P. pusana* are either synonyms or they are two varieties of one and the same species. He, however, retains these two species only due to the fact that the type specimen of *P. perpusilla* was not available to him for study.

The present writers took up the work in order to determine the species injuring sugarcane plants at Aligarh. Specimens were collected or acquired from various parts of the country. The collection thus raised included forms specially from Lyallpur (Punjab), Muzaffarnagar (United Provinces), Aligarh (United Provinces), Etah (United Provinces), Pusa (Bihar), Dacca (Bengal), Bhopal (Central India), Bombay, Coimbatore (Madras) and Ceylon.

The detailed morphological study of *Pyrilla* which is being conducted at the Aligarh Muslim University and is subsidized by the Imperial Council of Agricultural Research has proved of great avail in getting a clearer view of the characters on which different workers have based the distinction of different species.

Baker has based his classification of the species of *Pyrilla* on the contour of the rostrum and number of apical and sub-apical cells of the fore-wing. There is, however, a great variation and a regular gradation of these characters among the individuals of apparently the same species. With regard to the number of apical and sub-apical cells not only do the different sexes of the same species show a wide range of variability but even the right and left wings of the same individual differ in the number of these cells. It, therefore, often leads to a confusion while identifying one species from the other.

Baker's [1925] work is followed by that of Pruthi [1937]. Pruthi deals only with the male genitalia. This seems to be a limited view of the body structure of an entire organism and has apparently failed him to distinguish some of the well-defined species of the Indian sugarcane leaf-hoppers. The present work deals only with the description and identity of the Indian forms. The study of all the species occurring in the whole of oriental region is postponed for some later period when the present exigencies of war will be changed into more favourable conditions required for the work of this nature. The present writers avail of this opportunity to thank Dr H. S. Pruthi, Imperial Entomologist, for giving them access to the collection of *Pyrilla* present in the museum of the Imperial Agricultural Research Institute, New Delhi, and for providing opportunity of examining specimens identified by himself as well as by Distant. We acknowledge with gratitude the financial assistance of the Imperial Council of Agricultural Research and the help of the Entomologists-in-Charge of the above-mentioned sugarcane field stations in India and Ceylon for sending us the required material. Finally we are thankful to Dr M. B. Mirza, Chairman, Zoology Department, Muslim University, Aligarh, for providing all possible facilities and offering useful suggestions during the course of these studies.

The studies of the present writers have led them to the conclusions that in India two distinct species are found. They are *P. perpusilla* Walker, and *P. pusana* Distant. The specimens obtained from Ceylon are, however, quite different from those collected from any part of India. They are regarded by us as *P. aberrans* Kirby. A general description of these three species together with their distinctive features is given below :—

Pyrilla perpusilla Walker, (Pyrops) *List Hom.*, (ii), [1851] ;
Fauna Br. India, Heteroptera-Homoptera, vol. 3, [1906] ;
Treubia, vol. 6, [1925.]

The best specimens of this species were obtained from Bhopal and Bombay. It is, however, widely distributed all over India, chiefly at Lyallpur, Muzaffarnagar, Pusa, and in various Central and South Indian sugarcane tracts.

A typical male specimen has a uniformly ochraceous coloured body, slightly paler beneath than above. The body (Fig. 1-A) is much less robust than either *P. pusana* or *P. aberrans*. Fore-wings (Fig. 2-A) are semi-opaque,

more or less uniformly yellowish brown. Minute black spots are sparsely distributed all over the wing. The number of apical and sub-apical cells is highly variable and offers no sound characteristic of the species. Cephalic process (Fig. 1-a) is well developed. It is nearly two-fifth of the body length and is proportionally much longer than that of *P. pusana*. The dorsal margin of the cephalic process is generally parallel with that of the body (Fig. 1-A) and in a few cases slightly curved upwards at the tip. Male genitalia (Fig. 3-A) are very much smaller than those of either *P. pusana* or *P. aberrans* and are slightly different morphologically from either of them.

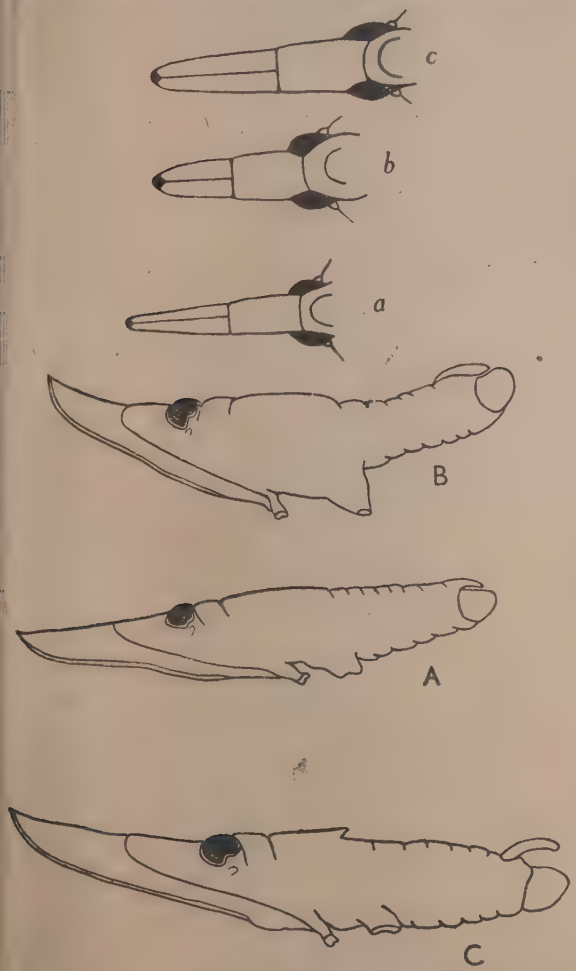


Fig. 1. Cephalic processes and body outlines of *P. perpusilla*, *P. pusana* and *P. aberrans* : a, b, c, cephalic processes ; A, B & C, body outlines (×8)

Dorso-lateral margin of the ninth sternum (Fig. 4-A) which provides reliable morphological distinction between these three species is provided with a dome shaped elevation nearly in the middle. The tenth tergum (Fig. 5-A) which carries the anal tube is slightly concave and broadly truncated at the apex.

Female. The above description applies equally to the female. Female genitalia (Fig. 6-A) like those of the male are much smaller than those of *P. pusana* and *P. aberrans* and are also slightly different structurally.

Pyrilla pusana Distant. *Ann. Mag. Hist.*, (8), 14 [1914] ; *Fauna B. India Rhynchota*, vol. 6, *Homoptera Appendix* [1916]. Good specimens of this species were obtained from Dacca (Bengal). This species as mentioned above is widely distributed in this country.

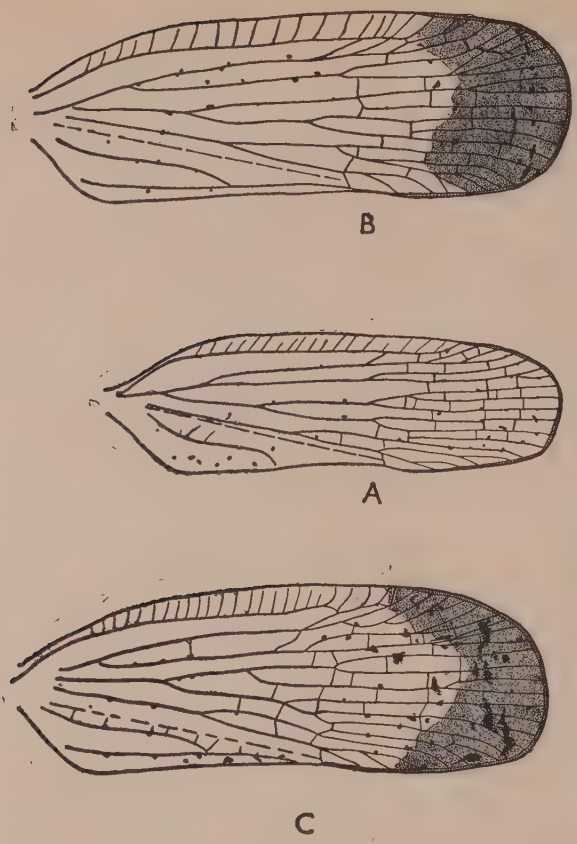


FIG. 2. Tegmina of *P. perpusilla* (A), *P. pusana* (B) and *P. aberrans* (C) (×8)

In male, the body (Fig 1-B) is much more robus and darkly coloured tha that of *P. perpusilla* Tegmina are dar ochraceous, the apica third (Fig. 2-B) bein much darker in hue tha the rest of the wing Black spots are chiefl distributed in the apica region.

Cephalic process (Fig 1-B) is comparativel much shorter than tha of *P. perpusilla* or *P aberrans*, strongly u curved towards the end Its length is less tha one-third of the tota length of the body. Th dorsal margin is not i line with that of the body but forms a saddle wit it. Number of apica and sub-apical cells i very variable in differen individuals as well as i different sexes. Tergum of the tenth segment (Fig. 5-B) is strongly

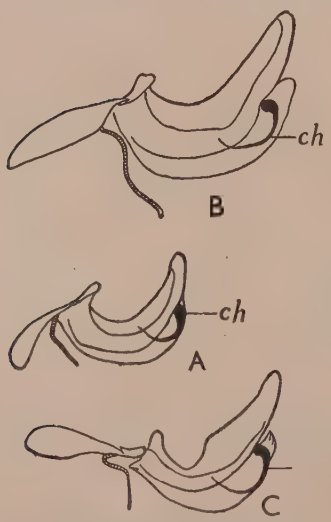


FIG. 3. Male genitalia of *P. perpusilla* (A), *P. pusana* (B) and *P. aberrans* (C); ch = conject-

convex at the base and broadly truncated a the tip. Male genitalia (Fig. 3-B) are much larger than those of *P. perpusilla*. Conjec tival hook of the phallus is very strongly developed and slightly twisted in the middle Each of the dorso-lateral margins of the ninth sternum has a knob-like process, not in the middle like *P. perpusilla*, but at the end of the proximal one-third of it (Fig. 4-B).

Female. The female has approximately the same structure as the male. Female genitalia are larger in size than those o *P. perpusilla* and are slightly different i structure as well.

The correct identification of this species has been a matter of great confusion especi ally in India. Baker has expressed his doubts regarding the validity of this species. He had no specimen of this species for his study

d thus failed to distinguish it from *P. aberrans*. Pruthi's statement that *aberrans* is unknown in India is probably correct. In the present study specimen of Indian species of *Pyrilla* was found to be *P. aberrans*. It is fortunate that Distant has incorrectly identified some of the Indian forms *P. aberrans*. A close study of such specimens in conjunction with form nd in Ceylon will show a considerable morphological difference. The sen writers, therefore, conclude that there are only two species of *Pyrilla* India. One of them is *P. perpusilla* Walker, and the other is *P. pusana* tant. A re-description of *P. aberrans* Kirby is given below, as Kirby's cription is not adequate to enable field workers to distinguish it from a sely allied species *P. pusana*.

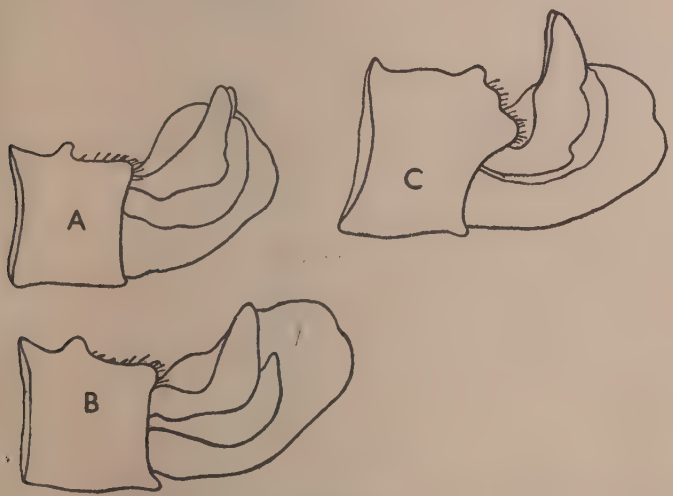
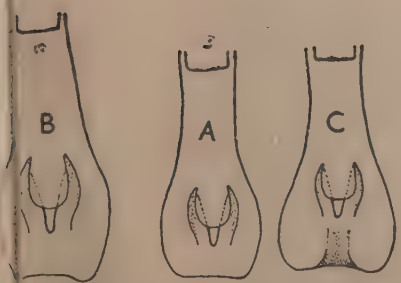


FIG. 4. Ninth segment with male genitalia of *P. perpusilla* (A), *P. pusana* (B) and *P. aberrans* (C) (×28)



5. Tenth tergum with anal tube of *P. erpusilla* (A), *P. pusana* (B) and *P. aberrans* (C) (×28)

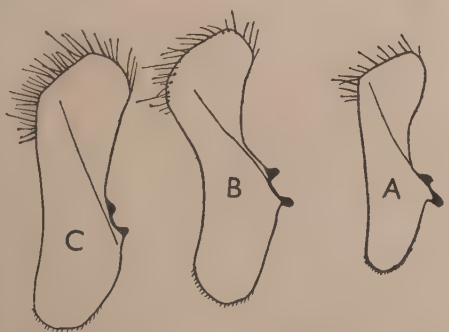


FIG. 6. Lateral valve of the ovipositor of *P. perpusilla* (A), *P. pusana* (B) and *P. aberrans* (C)

Pyrilla aberrans Kirby (Microchoria), *J. Linn. Soc. Zool.* 24, [
Melich. Hom. Faun. Ceylon, [1903] ; (*Zamila aberrans*), *Fauna B.*
Rhynchota, vol. 3 [1906] ; *Treubia*, vol. 6 [1925]. The specimens obtained
Ceylon were quite fresh and well preserved. In male, the body (Fig.
is quite robust, with yellowish-brown colour. Abdominal tergites are
picuously reddish-brown. Fore-wings are ochraceous, the apical third
much darker than the rest. Black spots are chiefly distributed in the a
half and in many cases form two short transverse fuscous lines near the a
margin. Cephalic process (Fig. 1-C) is comparatively much longer
in *P. pusana*, nearly two-fifths as long as the entire body, and is curve
wards at the apex. The number of apical and sub-apical cells are va
in different individuals of the same sex as well as of different sexes. Te
of the tenth segment (Fig. 5-C) is considerably different either
P. perpusilla or *P. pusana* and is deeply furrowed in the middle of its distal
Male genitalia (Fig. 3-C) resemble those of *P. pusana* in broad outlines.
dorso-lateral margin of the ninth segment (Fig. 4-C), however, pre
an important morphological distinction and appears to be a characte
of this species. Unlike *P. pusana* and *P. perpusilla* it is divided into
parts, one antero-dorsal margin with three short elevations and the
postero-dorsal margin which is quite long and almost plain.

Female. The above description applies to the female as well, e
or the characters particular to that sex.

Summary

The above work contains a brief review of the studies on the I
species of the sugarcane leaf-hopper *Pyrilla* Stal. It has been shown th
India two well-defined species are distributed at various places. They
P. perpusilla Walker and *P. pusana* Distant. A general description o
external morphology and various distinguishing features of the Indian sp
together with those of *P. aberrans* Kirby from Ceylon has been given
essential details.

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DIFFERENTIATION OF HYDROGEN CLAYS AND HYDROGEN BENTONITES AND IDENTIFICATION OF MINERAL CONSTITUENTS CONTAINED IN THEM BY ELECTRO-CHEMICAL METHODS

I. KAOLINITE AND KAOLINITIC CLAYS*

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(With six text-figures)

THE hydrogen clay isolated from soil usually consists of one or more crystalline secondary silicate minerals and varying quantities of 'free' oxides of Si, Al and Fe. The identification of the mineral constituents is of great interest and several physical methods, e.g. x-ray, optical and thermal analyses have been requisitioned for this purpose. Limitations of these methods are, however, known [Nagelschmidt, 1939]. They often do not go beyond indicating the group to which the mineral constituent of a given hydrogen clay belongs. Distinction between closely related individual members of the same group such as montmorillonite and beidellite is beset with considerable difficulties. Besides, all these methods throw very little light on their electro-chemical character which, after all, is most important as it determines the base exchange and many other chemical and physical properties of clays and soils.

The problem may be approached from an altogether different direction which does not appear to have been explored so far. It may be called the electro-chemical method of approach. The soil is essentially an electro-chemical or polar system and the central connecting theme in the electro-chemistry of soil is its dominant acid character. The hydrogen clay is the extreme acid form of the inorganic absorption complex obtained from soil. The electro-chemical properties of hydrogen clays isolated from several typical Indian soils have been discussed in previous publications [Mitra, 1936, 1940, 1942 ; Mukherjee

*The results given in this paper have been taken from the published Annual Report for 1940-41 on the working of a scheme of research financed by the Imperial Council of Agricultural Research, India

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(J. N.), Mitra and Mukherjee (S), 1937 ; Mitra, Mukherjee (S) and Bagch 1940 ; Mukherjee (J. N.), Mitra, Chatterjee and Mukherjee (S. K.), 194 Valuable information for purposes of identifying the mineral constituents of hydrogen clay and differentiating it may be obtained on comparing its ele tro-chemical properties with those of standard specimens of clay minera For sometime past studies of the more important of these minerals have bee under way in this laboratory which have this object in view. This pap deals with the titration curves and other electro-chemical features of kaolini and hydrogen clays prepared from the entire clay fraction of two laterit soils which gave dehydration curves similar to those of kaolinitic minera Alterations in some properties of these hydrogen clays consequent on t removal of their free inorganic oxides by the method of Truog *et al.* [193 have also been recorded. A separation of these free oxides is desirable an as will be shown later, even necessary for the identification of the miner constituents of the above hydrogen clays by the electro-chemical method.

TABLE I

Particulars regarding soils, hydrogen clays and sample of kaolinite used

Lab. No.	Description of soil or mineral	Silica/sesquioxide ratio of entire clay fraction	Reference No. corresponding hydrogen clay or hydrogen kao linite
MI	Kaolinite from Singhbhum .	1·99	H-kaolinite
22	Red lateritic soil (acidic) from Government Farm, Dacca (Bengal), collected at a depth of 0 to 6 in.	1·99	L ; L_d *
33	Bhata red laterite soil from Bilaspur (Central Provinces) collected at a depth of 0 to 6 in.	1·88	N ; N_d *

*Prepared from the entire clay fractions after separation of free inorganic oxides the method of Truog *et al.* [1936].

EXPERIMENTAL

Details of procedure adopted for the preparation of the hydrogen clay their chemical analysis and the electro-chemical measurements including ele trometric titration and estimation of base exchange capacity have been de cribed elsewhere [Mitra, 1936, 1940]. The dehydration curves were obtain by the method of Kelley *et al.* [1936]. The hydrogen kaolinite was obtain on repeatedly leaching with 0·02*N* HCl the entire clay fraction separat from a 2 per cent suspension of the powdered air-dried sample.

RESULTS

A. *Properties of hydrogen kaolinite*

(*a*) *Chemical composition and dehydration curve*

Fusion analysis of the hydrogen kaolinite gives SiO_2, 53·9 per cent Al_2O_3, 45·5 per cent ; and Fe_2O_3, 0·5 per cent. Al_2O_3, $2SiO_2$ requires SiO

55 per cent ; and Al_2O_3, 44·45 per cent. The dehydration curve of the linite given in Fig. 1 has the same form as reported by Kelley *et al.* 36].

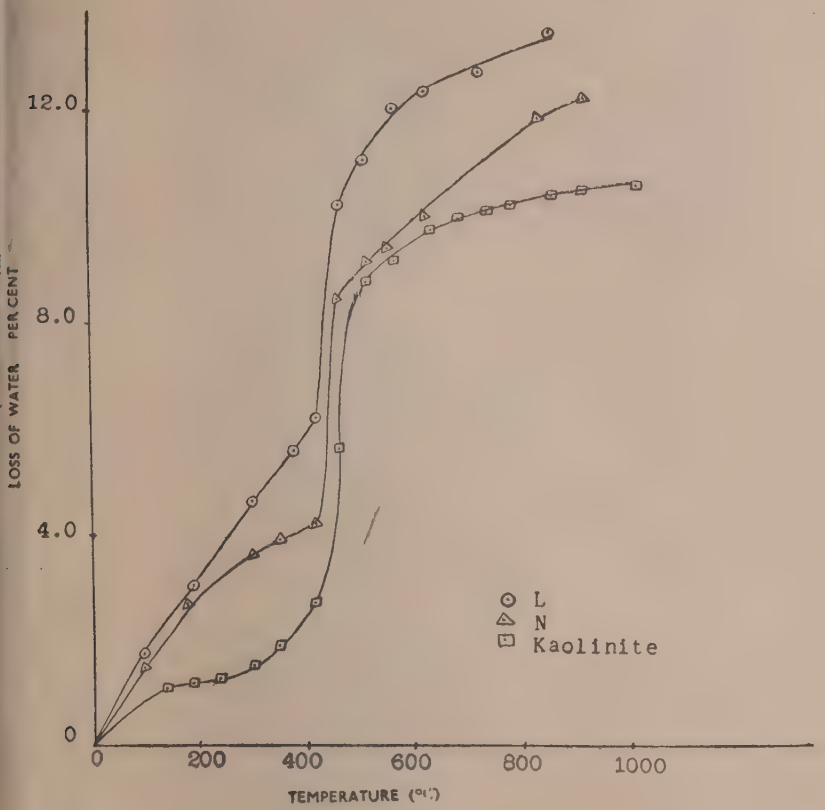

FIG. 1. Dehydration curves of hydrogen clays and hydrogen kaolinite

Existence of mobile H^+ions associated with the colloidal particles

As previously observed with electrodialyzed silicic acid and hydrogen sols [Mukherjee, Mitra and Mukherjee, 1937 ; Mitra, 1936, 1940, 1942 ; terjee, 1939] the colloidal particles of a stable sol of the hydrogen kaolinite with them mobile, i.e. osmotically active, hydrogen ions in electrical ble layers surrounding the particles. This is evident on a comparison of pH values of several hydrogen kaolinite sols with those of their ultrafil- s recorded in Table II. The sol has a much lower *p*H than its ultrafil- . The difference between the two *p*H's increases with the colloid content e sol and illustrates the so-called suspension effect of Wiegner and nann [1929].

TABLE II

pH values of hydrogen kaolinite sols and their ultrafiltrates

Colloid content in gm. per litre	*p*H of sol	*p*H of ultrafiltrat
25·0	4·41	6·15
12·5	4·98	6·15
6·25	5·45	6·35
2·50	5·66	6·40

(*c*) *Osmotic and conductivity coefficients of the mobile H^+ions*

In Table III the observed specific conductivities of the above hydr kaolinite sols have been compared with the values given by the expre

$$\frac{C_{H^+}}{1000}(U_{H^+} + {}^{+}V_{coll})$$

where C_{H^+} is the free acidity, and U_{H^+} and V_{coll} are respectively the mobi of H^+ion and the colloidal anion*.

TABLE III

Observed and calculated specific conductivities of hydrogen kaolinite s

Colloid content of sol in gm. per litre	Sp. conductivity $\times 10^6$ mho	
	Observed**	Calculated
25·0	17·0	16·5
12·5	5·8	4·3
6·25	1·6	1·5
2·50	0·95	0·92

The observed and calculated values show satisfactory agreement the case of hydrogen clays and hydrogen bentonites, on the other hand observed values have been found to be much smaller than the calculated [Mitra, 1938, 1940 ; Hauser and Reed, 1937]. The difference is probabl sociated with the peculiarities of the structure of the various systems an manner of distribution of the ions in the double layer associated with th loidal particles.

*For V_{coll} the value 20 has been taken

**Corrected for the sp. conductivity of the ultrafiltrates

) *Features of titration curves with bases*

Fig. 2 shows the titration curves, potentiometric and conductometric, a 0·25 per cent suspension of the hydrogen kaolinite with dilute $Ba(OH)_2$. milar titration curves are obtained with NaOH and $Ca(OH)_2$. The poten- ometric curves with all three bases are shown in Fig. 3.

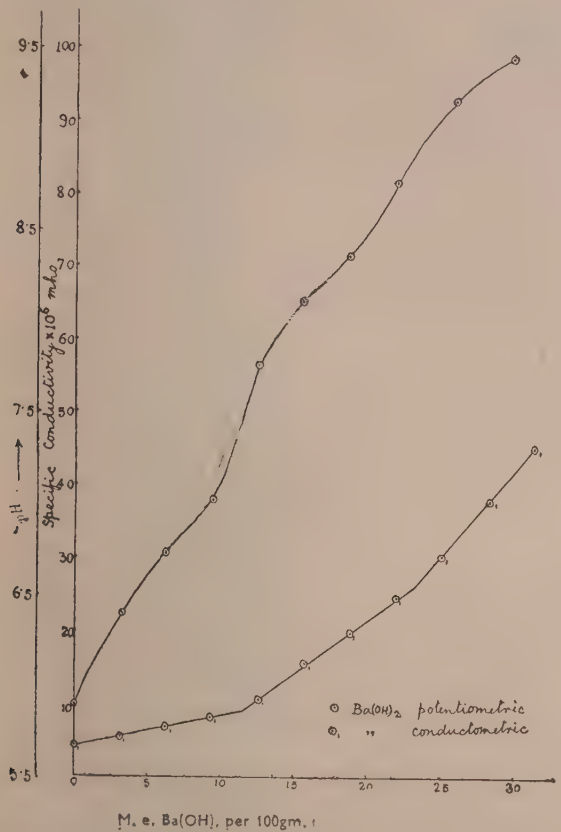

FIG. 2. Potentiometric and conductometric titration curves of hydrogen kaolinite with baryta

The potentiometric and conductometric curves (with all three bases) oint to a weak dibasic acid character of the hydrogen kaolinite. No further flexion point was observed on extending the titration (with 10*N* NaOH) *p*H 11·5.

The potentiometric titration curves with NaOH, $Ba(OH)_2$ and $Ca(OH)_2$ ough having the same form are not superimposable but have different slopes any given *p*H (Fig. 3). The amount of the base required to reach a fixed H is in the order $Ca(OH)_2 > Ba(OH)_2 > NaOH$. The bases thus react with e sols in the same order. Similar observations have been previously made

with hydrogen clays and hydrogen bentonites [Mukherjee (J. N.), Mitra Mukherjee (S.), 1937 ; Mitra, 1936, 1940, 1942 ; Mukherjee (J. N.), M Chatterjee and Mukherjee (S. K.), 1942]. The dependence of the react of the base on the nature of its cation designated by Mukherjee, Mitra Mukherjee [1937] as the irregular or specific cation effect is probably assoc with the adsorbability of the cations in the dehydrated condition. greater the adsorbability the larger is the quantity of H^+ ions displaced the double layer and neutralized at a fixed pH.

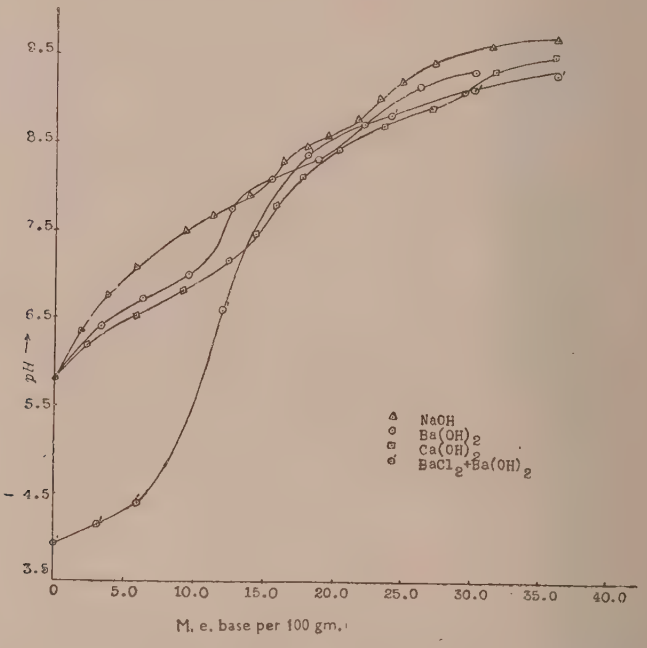

FIG. 3. Potentiometric titration curves of hydrogen kaolinite with different ba

Fig. 3 also gives the potentiometric curve obtained on titrating the supernatant liquid above the coagulum of a mixture of the hydrogen kao and N $BaCl_2$. This curve, unlike that of the hydrogen kaolinite alone the appearance of that of a strong monobasic acid. This is expected a supernatant liquid above the sol+salt mixture contains free H^+ ions disp from the double layer by the cations of the added $BaCl_2$. Features expected if Al^{+++} ions were present are not noticeable in the curve. conclusion is supported by the analysis of the supernatant liquid which s that aluminium is present in negligible quantities. The hydrogen kao in this respect differs from hydrogen clays and hydrogen bentonites. Ne salt extracts of the latter almost invariably contain appreciable quantit Al^{+++} ions [Paver and Marshall, 1934 ; Mukherjee and Chatterjee, 1 Chatterjee and Paul, 1942].

(e) *Degree of dissociation and dissociation constant of hydrogen kaolinite*

The degree of dissociation, α (given by the ratio of the free acid to the total acid* at the second inflexion point), of a 0·25 per cent suspension and the first and second dissociation constants K_1 and K_2 given by the *p*H values at 50 per cent neutralization referred respectively to the first and second inflexion points are recorded in Table IV. The last column of the table gives the second dissociation constant K_2^1 calculated from the equation $K^1{}_2 \frac{^2c}{1-\alpha}$ where c is the total acid at the second inflexion point.

TABLE IV

Degree of dissociation and dissociation constants of hydrogen kaolinite sols

Base used	$\alpha \times 10^2$	$K_1 \times 10^7$	$K_2 \times 10^8$	$K^1{}_2 \times 10^8$
NaOH . . .	0·39	0·8*	2·4	2·9
$Ba(OH)_2$ . .	0·41	2·3	7·4*	2·6
$Ca(OH)_2$ . . .	0·30	2·6	4·5	6·0*

α has a very small value. This is in agreement with the weak acid character of the titration curves of the hydrogen kaolinite and the low values of the dissociation constants recorded in Table IV. However, the same value of neither α nor K_1 or K_2 is obtained from the titration curves with all three bases as would be expected in the case of a weak acid in true solution. The small value of K_1 and K_2 rather shows that the greater part of the H^+ ions is present in a bound condition [Mukherjee, 1921, 1922] in electrical double layers surrounding the colloidal particles.

An approximate agreement between the different values of K_1 as also of K_2 is obtained if those marked with an asterisk (*) in Table IV are neglected. K_1 is then roughly ten times K_2.

(f) *Base exchange capacity of hydrogen kaolinite*

The base exchange capacities (b.e.c.) calculated from the titration curves are recorded in Table V.

TABLE V

Base exchange capacity of hydrogen kaolinite calculated from titration curve

Base used	B. e. c. in m. e. base per 100 gm. of oven-dried hydrogen kaolinite		
	At 1st inflexion point	At 2nd inflexion point	At *p*H 7·0
NaOH . .	13·0(8·0)**	23·0(9·0)	5·0
$Ba(OH)_2$ . .	12·0(7·55)	22·0(8·7)	9·0
$Ca(OH)_2$ . .	15·5(7·70)	28·0(9·04)	11·0

*It will be shown later that the total acid or the base exchange capacity calculated at the first or second inflexion point is not a fixed quantity but depends on the cation of the base used for the titration.

** The figures in brackets denote the *p*H at the inflexion point.

The three bases do not give the same b. e. c. Calculated at a fixed *p*H e.g. *p*H 7·0, it decreases in the order $Ca(OH)_2 > Ba(OH)_2 > NaOH$ i agreement with the irregular or specific cation effect. Calculated at th first or second inflexion point, however, the b. e. c. follows the orde $Ca(OH)_2 > NaOH > Ba(OH)_2$. The smaller relative effect of Ba(OH) compared with NaOH is really due to the lower *p*H at the inflexion point i the titration curve with $Ba(OH)_2$ than with NaOH. The *p*H effect thu masks the cation effect [Mukherjee, Mitra, Mukherjee and Chatterjee, 1942

The ratio of the b. e. c.'s at the second and first inflexion points in th titration curves with all three bases is very nearly—it is actually slightly les than—2 as would be expected in the case of a dissolved dibasic acid.

The base exchange capacities estimated by Parker's and Schofield' methods [Parker, 1929 ; Schofield, 1933] as also by titration with Ba(OH) in the presence of *N* $BaCl_2$ are given in Table VI.

TABLE VI

Base exchange capacity of hydrogen kaolinite estimated by different metho

Method	B. e. c. in m. e. per 100 gm.
(*i*) Parker	12·5(7·0)*
(*ii*) Schofield	10·6(7·1)
(*iii*) Titration with $Ba(OH)_2$ in the presence of *N* $BaCl_2$	15·0(7·0)

*The figures in brackets denote the *p*H at which the b. c. c. has been estimated

The b. e. c.'s obtained by the three methods are in the order (*iii*)> (*i*)> (*ii*). All three methods give values which are near about the b. e. c at the first inflexion point in the titration curves with bases (in the absenc of salts) but are much smaller than that given by the second inflexio point (Table V). The second inflexion point, therefore, indicates th neutralization of hydrogen ions which are present at a very high level o affinity and cannot be displaced from the double layer by such strongl adsorbed cations as Ba^{++} and Ca^{++} even when added in such high concen tration as 1*N* in methods (*i*) and (*iii*), and 0·05*N* in method (*ii*). It appear that the *p*H effect is more potent than the cation effect in the estimatio of these 'high affinity' hydrogen ions. In the above three methods the b. e. c. is estimated at a much lower *p*H than that at which the secon inflexion in the titration curves is observed.

Properties of hydrogen clays giving dehydration curves similar to that of kaolinitic minerals

The chemical compositions and the base exchange capacities calculated
n titration curves are given in Tables VII and VIII. The titration
es of L are shown in Fig. 4. N gives similar titration curves and these
e been omitted. The titration curves of L_d and N_d (obtained from
nd N after separation of the free oxides by the method of Truog *et al.*
6]) are given in Figs. 5 and 6. The dehydration curves are shown in
1.

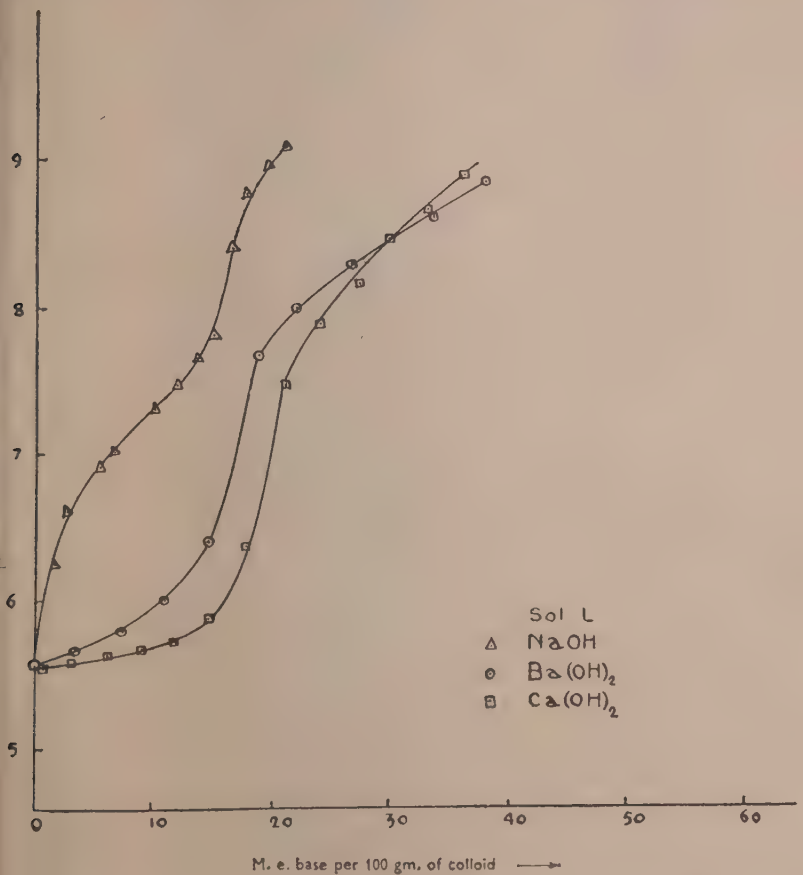

FIG. 4. Potentiometric titration curves of hydrogen clay L with different bases

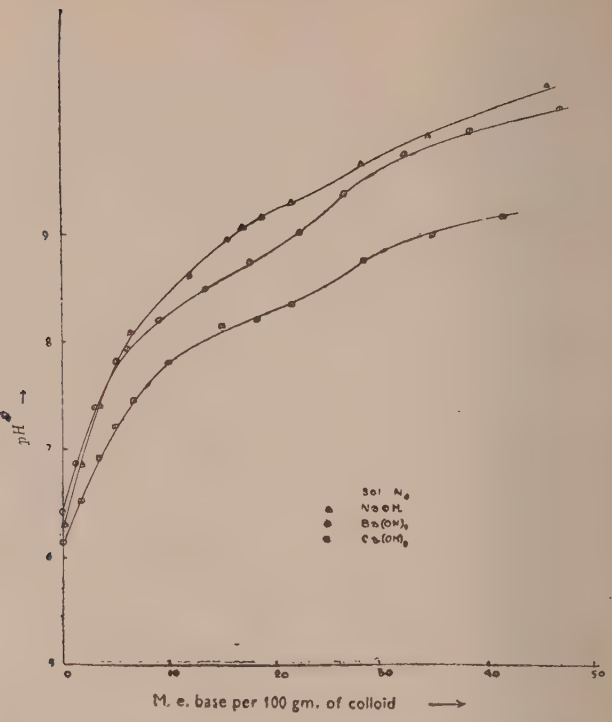

FIG. 5. Potentiometric titration curves of hydrogen clay L_d with different

TABLE VII

Chemical compositions of hydrogen clays before and after separation of their inorganic oxides

Reference number of hydrogen clay	Chemical composition on the ignited basis		
	SiO_2 (per cent)	Al_2O_3 (per cent)	Fe_2O_3 (per cent)
L	51·2	36·0	12·0
Ld	57·5	38·0	5·7
N	42·6	3·7	54·2
Nd	61·0	34·3	4·6

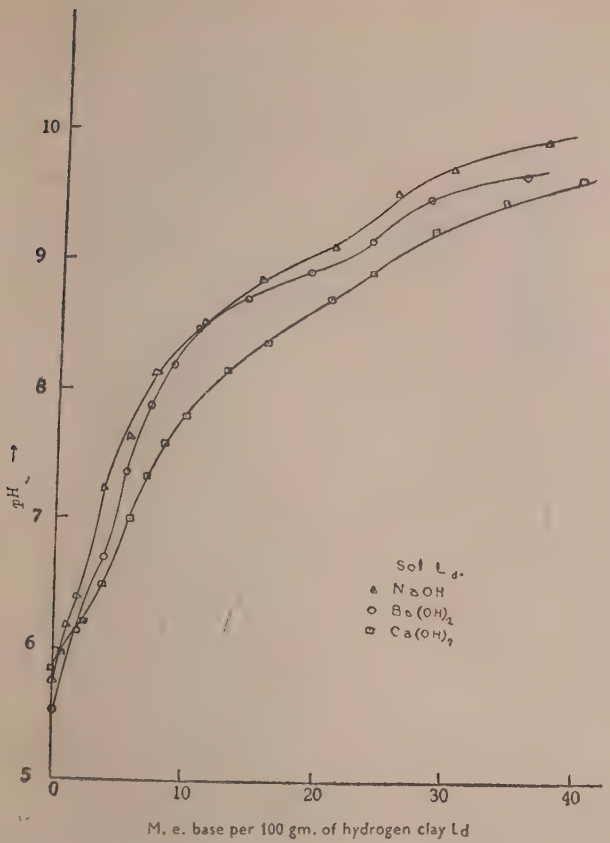

FIG. 6. Potentiometric titration curves of hydrogen clay N_d with different bases

TABLE VIII

ase exchange capacity of hydrogen clays before and after separation of their free inorganic oxides

Reference number of hydrogen clay	B. e. c. in m. e. per 100 gm. of hydrogen clay at inflexion point of titration curve with		
	NaOH	$Ba(OH)_2$	$Ca(OH)_2$
L	16·3(8·2)*	17·5(7·1)	19·0(6·8)
L_d	4·0(7·1) ; 24·5(9·5)	5·0(7·16) ; 23·5(9·0)	5·5(7·0) ; 25·0(9·06)
N	18·8(7·5)	19·0(7·0)	20·5(6·5)
N_d	26·5(9·5)	28·4(9·5)	27·0(8·6)

*The figures in brackets denote the *p*H at the inflexion point of the titration curve

The dehydration curves of L and N (Fig. 1) have features common wi those of the kaolinite*. The adsorbed water forms a comparatively sm percentage of the total water and the inflexion point lies near about 400° The titration curves, however, present quite dissimilar features. Thus t dibasic acid character observed with the hydrogen kaolinite (Figs. 2 and is not shown by the titration curves of L (Fig. 4) and N. Moreover, wh the NaOH curve of these two hydrogen clays resemble that of a we monobasic acid, their $Ba(OH)_2$ and $Ca(OH)_2$ curves reveal a strong moderately strong acid character. These features have been observed with t majority of the hydrogen clays studied by us [Mitra, 1940, 1942; Mukherje Mitra, Chatterjee and Mukherjee, 1942].

Unlike L and N, the derivatives L_d and N_d behave as a weak acid judg from the form of their titration curves with all three bases (Figs. 5 and Like the hydrogen kaolinite, the titration curves of L_d have the appearance that of a weak dibasic acid. The base exchange capacity at the seco inflexion point has nearly the same value (about 25 m.e. per 100 gm.) a occurs at approximately the same pH (near about 9·0). The base exchan capacity at the first inflexion point of L_d, however, has a definitely lower val than the hydrogen kaolinite and it occurs at a lower pH.

The chemical composition of L_d approaches that of the hydrogen kaolini The chemical, electro-chemical and dehydration data thus all lead to t conclusion that kaolinite is the dominant mineral constituent of the clay fra tion of the Dacca lateritic soil. Free inorganic oxides contained in L probab mask the electro-chemical features characteristic of kaolinite. These featu are, however, observed in the derivative L_d.

Unlike L_d, N_d does not behave as a dibasic acid. Its titration curves reveal a weak monobasic acid character. Their inflexion point, howev occurs in the same range of pH (8·5 to 9·5) as the second inflexion in the titr tion curves of L_d and the hydrogen kaolinite. The base exchange capaci of N_d calculated from the only inflexion point in its titration curve has a proximately the same value (near about 25 m. e. per 100 gm.) as the ba exchange capacities of L_d and the hydrogen kaolinite calculated fro the second inflexion point.

The chemical composition of N_d is also materially different from that kaolinite. The chemical and electro-chemical evidences obtained with N a N_d can be reconciled with the dehydration data if it is assumed that (*a*) contains kaolinite or more probably some other mineral of the kaolin grou mixed with some free oxides which have not been completely removed as result of the treatment given for this purpose and which are, therefore, n altogether absent in N_d and/or that (*b*) in addition to a large percentage of kaolinitic mineral N and N_d contain one or more secondary clay minera belonging to a different group.

Summary

Marked acidic properties are shown by a hydrogen kaolinite prepare from the entire clay fraction of a sample of kaolinite from Singbhum (Benga

*That the curves are not exactly similar may be due to several factors, e.g. lar differences in the average size of the particles [Kelley, *et al.* 1936], presence of small qua tities of minerals other than those of the kaolin group, etc.

repeatedly leaching it with dilute hydrochloric acid. Its potentiometric nd conductometric titration curves with NaOH, $Ba(OH)_2$ and $Ca(OH)_2$ all veal a weak dibasic acid character. The first and second dissociation nstants are of the order of 10^7 and 10^8 respectively. The ratio of the base change capacities raise at the second and first inflexion points is very arly 2·0 and the base exchange capacity at the second inflexion point is out 25 m.e. per gm.

The hydrogen clay prepared from a red lateritic soil from Dacca which ves a dehydration curve similar to that of kaolinitic minerals also shows a eak dibasic acid character after separation of its free inorganic oxides by the ethod of Truog *et al.* and the base exchange capacity at the second inexion point is near about 25 m.e. per 100 gm. If the free oxides are not moved this hydrogen clay behaves as a monobasic acid judged from the ature of the titration curves. The dibasic acid character is not observed titrating another hydrogen clay prepared from a Bhata red laterite soil ther before or after removal of its free inorganic oxides by the above method, ough this hydrogen clay also gives a dehydration curve similar to that kaolinitic minerals.

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SELECTED ARTICLE

GENE SYMBOLS FOR USE IN COTTON GENETICS*

BY

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GENETIC work on cotton has reached a stage where the haphazard allocation of gene symbols adopted in the past has become inconvenient and confusing. We have listed the cotton genes of which descriptions are known to us and attempted to adjust their nomenclature in accordance with accepted genetic conventions and with regard to the special circumstances obtaining in the genus Gossypium.

The conventions we have adopted are as follows :

(1) Multiple allelomorph series : A series of alphabetic superscripts to a common gene symbol, e.g. the leaf shape series, L^B, L^I, L^L, L, l.

(2) Duplicate factors : The same gene symbol with numerical subscripts, e.g. the chlorophyll deficient duplicates, Chl_1, chl_1 : Chl_2, chl_2.

(3) Complementary factors : The same gene symbol with alphabetic subscripts, e.g. complementary crumpled, Cp_a, cp_a : Cp_b, cp_b.

A special difficulty arises in the nomenclature of cotton genes. Many characters occur in both Old World and New World groups, and frequently in the wild species also. Their genetic basis is usually similar, and in one case it has been shown that the controlling genes are homologous[9]. It is, therefore, desirable to have a common gene terminology throughout, but the high degree of sterility in crosses between groups makes the demonstration of homology a slow and difficult undertaking. We propose, therefore, that the nomenclature of the Old World ($2n=26$) cottons be taken as the basis, and genes controlling homologous characters in the New World cultivated and Polynesian wild ($2n=52$) and New World wild ($2n=26$) species will be given the same symbols, but printed in ordinary type until homology has been proved, and then in italics.

Our proposals for the anthocyanin multiple allelomorph system require special explanation. The original series established in Asiatic cottons[16] consisted of six members. The two lowest members were spotless, and the four higher members, in addition to giving red petal spot, determined progressive extension of vegetative anthocyanin expression. The six members were arranged serially, R, R^L, R^C, R^S, rg, r^o. Recently, however, a spotless equivalent

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TABLE I

List of recorded genes in cotton and their present and proposed symbols

(See text for explanation of nomenclature)

Character	Old World (2n = 26) cottons			New World (2n = 52) cottons		
	Gene effect	Present symbol and authority	Proposed symbol	Gene effect	Present symbol and authority	Proposed symbol
Chlorophyll deficiency	green-chlorophyll deficient	(30)*	*Chl*	green-chlorophyll deficient	c^{ha} (11,39)	Chl_1
				deficient duplicate	$c^{1.b}$	Chl_2
	green-virescent yellow	V_1 (45)	*No alteration*	green - virescent yellow	v (26)	v
Crumpling	crumpled (complementaries)	A (16)	Cp_a			
		b	Cp_b			
Crinkled dwarf				normal-crinkled	Cr (5)	Cr
Cluster habit				normal-cluster	C^1 (40)	Cl
Short fruiting branches				long-short sympodia	S^h (24)	Sh
curly leaf	curly	Cu (45)	*No alteration*			
Leaf shape	mutant broad	L^E (16)				
	mutant intermediate	L^I				
	laciniated	L^L	*No alteration*	super-okra	O^S (10,32)	L^4
	narrow	L		okra	O^O	L^o
	broad	l		normal	O^n	l
Leaf nectaries	present - absent	(27)	*Ne*			
Anthocyanin	Spotted series			Spotted series		
	red plant body	R (17)	R_3^{ex}			
	red leaf	R^L	R_1^{ex}	red leaf	$R^2{}_1{}^{3w}{}_1{}^{3o}$.(6. 9, 10, 23)†	R_1^{Lw} (12)
	red calyx	R^C	R_3^{Cs}			
	tinged stem	R^S	R_2^{AS}	tinged stem	$S^s{}_1{}^i{}_2{}^f$ (6)	$R_2^{AS\ AL\ AP}$
	green stem	r^S	R_2^{os}			
	Spotless series			Spotless series		
	red leaf	R_2^O (22)	R_1^{Lo}			
	tinged stem	r^O	R_2^{AO}	tinged stem	S^O (6)	R_2^{AO}
	Duplicate (ex G. anomalum)		R_3^{Ou} (34)	Duplicate red spotless	R^1 (3,10,28, 40,42,44)	R_1^{ou}
	Spot reducer		*Sr* (22)			
Corolla color	yellow petal	Y (15)	Y_a	yellow	Y^B (8, 14)	Y_1
	pale	Y^P	$Y_a{}^p$	cream	y	Y_1^o
	white	y	y_a			
	pale, complementary		$Y_a{}^r$ (34)			
	pale, complementary (ex. G. anomalum)		$Y_a{}^r$ (35)			
				yellow duplicate	Y^D (14)	Y_2
	yellow depressor		*Ydp* (36)			
Pollen color	yellow		$P_a P_a$	yellow	P (7)	P
	pale } complementary	(29)	P_b (38)			p
	cream }		p_a (38)	cream	p	
Meristic variant	increase in number of floral parts - normal	(30)	*M*			

* In this paper the authors refer to two types of chlorophyll deficiency, only one of which behave as a simple recessive. To the recessive we assign the symbol chl.

† Red leaf weak spot of Trinidad Red Leaf and red leaf extinguished spot of Cassava have both been transferred to the Sea Island background, on which they are indistinguishable. R^2S^w and R^3S^c are therefore identical and may be given the symbol R_2^{Lw}.

TABLE I—*contd.*

Character	Old World (2n = 26) cottons			New World (2n = 52) cottons		
	Gene effect	Present symbol and authority	Proposed symbol	Gene effect	Present symbol and authority	Proposed symbol
Sterility	fertile - sterile	(20)	*Stp*			
Female sterility	fertile - female sterile	Stg (41)	*No alteration*			
Petalody	normal - petalodic	F^{Pd} (31)	*Pdy*			
Boll dehiscence	more dehiscent - less dehiscent	(1)	*De*			
Lint colour	khaki - white	K (18)	Lc_1^K lc_1	khaki - white	K^H (13)	Le_1^c - l
	khaki, duplicate		Lc_2^K (33)	duplicate	K^B (13)	Le_2^n - l
	light brown	D_1 (19)	Lc_2^0 (33)			
	white		lc_2			
	light brown-white, duplicate	D_2 (19)	Lc_2^B - lc_2 (33)			
				green - white	G^L (9)	Lg
Lintlessness	hairy linted-glabrous lintless (complementary)	H^G (2)	H_a (21) H_b			
	hairy linted - hairy lintless (complementary)		Li_a (21) Li_b			
	hairy linted - hairy lintless (sometimes lethal)	$h^{L_H}L$ (2)	Li_a - li_a (21)*			
Seed fuzz				naked (low lint index)-fuzzy (Upland)	N,L (3,4,25, 40,43)	Fn
				tufted - naked (Peruvian)	T (9,10)	Ft
				less fuzzy - more fuzzy (Peruvian)	S^m (25. 10)	Fm
	tufted - fuzzy	T (19)	Fz	tufted - fuzzy (Upland)	F^t (3)	Fs
Seed fuzz colors				green - white	G (3)	Fgr
				brown - white	B^r (3)	Fbr

* Afzal & Hutchinson (2) assigned the capital letter (H^L) to the "dominant" lethal. Hutchinson & Godkari (21) showed that the heterozygote was strictly intermediate and the homozygote sometimes viable. On account of the close parallelism between Punjab hairy lintless and the recessive hairy lintless in *G. herbaceum* they assigned the capital letter (Li_a) to the normal gene.

of R^L has been described by Hutchinson and Ghose[22] and was given the symbo $R_2{}^0$. While this is satisfactory for genes now recognized, it seems to be desi able to devise a system of nomenclature which will cover any spotless type which may be found in the future. From the fact that the new spotless ty is, like r^0, complementary with rg with reference to petal spot[17-22] appears that there are probably at least two independent gene centres on th R protosome[18], affecting respectively petal spot and presence and distributio of anthocyanin. The probable relationship between the spotted and spotle series is shown below, where the proposed symbols are indicated. The presen ones are in brackets.

	Petal spotted		Spotless	
Red plant body	$R_2{}^{RS}$	(R)		
Red leaf	$R_2{}^{LS}$	(R^L)	$R_2{}^{LO}$	$(R_2{}^0)$

	Petal spotted		Spotless	
Red calyx	R_2^{CS}	(R^C)		
Red tinged stem (i.e. basic anthocyanin gene present, expression variable but slight)	R_2^{AS}	(R^S)	R_2^{AO}	(r^O)
Green stem, ghost spot (basic anthocyanin gene absent)	R_2^{AS}	(r^g)		

Such symbolisation has also been attempted for the New World cottons on the basis of phenotypic appearance. The fact that members of the New World R_2 series are printed in italics indicates only that homology of the locus with that of Asiatic cottons has been established. In no case is it intended to imply identity of allelomorphs.

In Table I are listed the characters that have been studied genetically, the gene symbols allotted to them, and the alterations we propose. The numbers in brackets refer to the list of reference attached at the end.

We are indebted to Drs. J.O. Ware and J. W. Neely of the United States Department of Agriculture, and to Mr. V. Ramanatha Ayyar of the Madras Department of Agriculture, who have criticized our manuscript and suggested a number of alterations which have been included in this list.

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REVIEW

Annual Review of Biochemical and Allied Research in India, Vol. XII, 1941
Society of Biological Chemists, India, Bangalore : pp. 84 : price Rs. 3 or 6*s*.

THIS review contains a faithful record of the activities of Indian workers in the field of biochemistry and allied subjects. Experts attached to representative institutions have been entrusted with the task of reviewing the work in branches.

Each of these reviews draws attention to the increased volume of work. Under soils and fertilizers, a short account is given of work done during the year on soils survey and classification, soil erosion, soil alkali and alkaline lands, physico-chemical properties of soils, methods of soil analyses, soil micro-organisms, nitrogen fixation and transformation in soils, soil conditions and crop production and manures and fertilizers. Under animal nutrition, research on the subjects of nutrition of livestock and dairy science have been reviewed. Work on vitamin-C contents of cow's milk and on various types of tinned milk, their food value, methods of manufacture, spoilage during storage have been included in this review. A review has been made of the quantitative and qualitative aspects of the existing food supply of the entire cattle population of India. In the same article, work on the digestibility and feeding value of oil seeds, on the effect of feeding berseem on growth and milk yield, on mineral requirements of cows and on nutritional requirements of chicken are summarized.

The publication of these annual reviews has been a regular feature of the activities of the Society of Biological Chemists for the last 12 years and for the valuable information it is supplying it can be regarded as an appendix to the world annual review of biochemistry.

ERRATA

Indian Journal of Agricultural Science

Vol. XII, Part III,

Page 495, line 5, *for* ' velatile ' *read* ' volatile '
Page 497, Fig. 2, *for* ' VI sample ' *read* ' IV sample '

Vol. XII, Part V, October 1942

Page 688, Table V (latter part), columns 1 and 5, first line, *for* ' W_3' *read* ' W_2
Page 688, Table V (latter part), heading of column 3, *for* ' D_3' *read* ' D_2'
Page 707, line 9, *for* ' as ' *read* ' at '
Page 708, heading of Table V, *for* ' or ' *read* ' of '
Page 718, line 4, *for* ' hte ' *read* ' the '
Page 746, line 5, *for* ' grow h ' *read* ' growth '
Page 753, line 14, *for* ' fertilissimal ' *read* ' fertilissima '
Page 753, line 16, *for* ' Basa ' *read* ' Basal '
Page 753, last line, *for* ' ittle ' *read* ' little '
Page 755, line 4, *for* ' [Singh, 1939 ' *read* ' [Singh, 1939] '
Page 755, line 10, *for* ' soil- ' *read* ' soils '
Page 755, line 11, *for* ' questios ' *read* ' question '
Page 755, line 12, *for* ' energyn ' *read* ' energy - '
Page 755, line 18, *for* ' p ants ' *read* ' plants '
Page 783, line 1, *for* ' thant wice ' *read* ' than twice '
Page 788, line 4, *for* ' have) ' *read* ' have '
Page 789, line 28, *for* ' clause- ' *read* ' clauses '

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DEHRA DUN—Jugal Kishore & Co.

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Indian Army Book Depot, Daryaganj.
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Oxford Book and Stationery Co.
Sharda Mandir, Ltd., Nai Sarak.
Young Man & Co. (Regd.), Egerton Road.

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HYDERABAD (DECCAN)—
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JAIPUR CITY—Garg Book Co.

KARACHI—
Aero Stores.
Standard Bookstall.

KARACHI (SADAR)—Manager, Sind Government Book Depot and Record Office.

LAHORE—
Kansil & Co., Messrs. N. C. 9, Commercial Buildings, The Mall.
Malhotra & Co., Messrs. U. P., Post Box No. 94.
Minerva Book Shop, Anarkali Street.
Punjab Religious Book Society.
Rama Krisnna & Sons, Anarkali.
Superintendent, Govt. Printing, Punjab.
University Book Agency, Kacheri Road.

LUCKNOW—Upper India Publishing House, Ltd., Literature Palace, Aminuddaula Park.

LYALLPORE—Lyall Book Depot.

MADRAS—
Higginbothams.
Superintendent, Govt. Press, Mount Road.
Varadachary & Co., Messrs. P.

MHOW—Universal Bookstall.

MOGA—Army Musketry Stores.

NAGPUR—
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Khot & Sons, Messrs. G. G., Sita Buldi, 3rd Modi Lane.
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NEW DELHI—
Bhawnani & Sons.
Jaina Book Agency, Connaught Place.
Ramesh Book Depot & Stationery Mart, Connaught Place.
Saraswati Book Depot, 15, Lady Hardinge Road.

PATNA—Superintendent, Government Printing, Bihar, P. O. Gulzarbagh.

PATNA CITY—
Lakhsmi Trading Co., Padri-ki-Haveli.
Raghunath Prasad & Sons.

PESHAWAR—
London Book Co. (India), Arbab Road.
Manager, Govt. Printing & Stationery, N.-W. F. P.

PESHAWAR CANTT.—Faqir Chand Marwah.

POONA—
Deccan Bookstall, Fergusson College Road.
Dastane Bros., Home Service, 456, Rawiwar Peth.
International Book Service.
Ram Krishna Bros., Opposite Bishram Bagh.

QUETTA—Standard Bookstall.

RAJKOT—Mohanlal Dossabhai Shah.

RANGOON—
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Curator, Govt. Book Depot, Burma.

RAWALPINDI—Ray & Sons, Messrs. J., 43, K. & L. Edwardes Road.

SHILLONG—
Chapala Bookstall.
Superintendent, Assam Secretariat Press.

SIALKOT CITY—Clifton & Co.

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VELLORE—Venkatasubban, Mr. A., Law Bookseller.

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